



SPC BENCHMARK 1™

FULL DISCLOSURE REPORT

**HUAWEI TECHNOLOGIES CO., LTD
HUAWEI OCEANSTOR™ 18500 V3**

SPC-1 V3.2

SUBMISSION IDENTIFIER: A31003

SUBMITTED FOR REVIEW: DECEMBER 27, 2016

Second Edition – February 2018

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Trademarks

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Benchmark Specification and Glossary

The official SPC Benchmark 1™ (SPC-1™) specification is available on the website of the Storage Performance Council (SPC) at www.storageperformance.org.

The SPC-1™ specification contains a glossary of the SPC-1™ terms used in this publication.

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AUDIT CERTIFICATION



Zhong Xu
 Huawei Technologies Co., Ltd.
 Huawei Industrial Base, Bantian,
 Longgang, Shenzhen city,
 Guangdong province, China

December 26, 2016

I verified the SPC Benchmark 1™ (SPC-1™ Revision3.2) test execution and performance results of the following Tested Storage Product:

HUAWEI OCEANSTOR™ 18500 V3

The results were:

SPC-1 IOPS™	2,340,241
SPC-1 Price-Performance™	\$0.55/SPC-1 IOPS™
SPC-1 IOPS™ Response Time	0.723 ms
SPC-1 Overall Response Time	0.537 ms
SPC-1 ASU Capacity	76,408 GB
SPC-1 ASU Price	\$16.84/GB
SPC-1 Total System Price	\$1,286,535.26

In my opinion, these performance results were produced in compliance with the SPC requirements for the benchmark.

The testing was executed using the SPC-1 Toolkit Version 3.0 Build d34fb3c. The audit process was conducted in accordance with the SPC Policies and met the requirements for the benchmark.

A Letter of Good Faith was issued by the Test Sponsor, stating the accuracy and completeness of the documentation and testing data provided in support of the audit of this result.

A Full Disclosure Report for this result was prepared by InfoSizing, reviewed and approved by the Test Sponsor, and can be found at www.storageperformance.org under the Submission Identifier **A31003**.

A31003

HUAWEI OCEANSTOR™ 18500 V3

p.2

The independent audit process conducted by InfoSizing included the verifications of the following items:

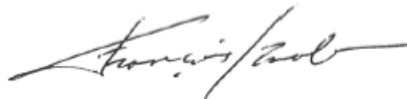
- The physical capacity of the data repository;
- The total capacity of the Application Storage Unit (ASU);
- The accuracy of the Benchmark Configuration diagram;
- The tuning parameters used to configure the Benchmark Configuration;
- The Workload Generator commands used to execute the testing;
- The validity and integrity of the test result files;
- The compliance of the results from each performance test;
- The compliance of the results from the persistence test;
- The compliance of the submitted pricing model; and
- The differences between the tested and the priced configuration, if any.

The Full Disclosure Report for this result was prepared in accordance with the disclosure requirements set forth in the specification for the benchmark.

The following benchmark requirements, if any, were waived according to the SPC Policies:

- None.

Respectfully Yours,



François Raab, Certified SPC Auditor

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LETTER OF GOOD FAITH



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 China
 Tel: 0086-755-28780808
<http://www.huawei.com/en/>

Date: December 27, 2016

From: Huawei Technologies Co., Ltd.

To: Mr. Francois Raab, Certified SPC Auditor
 InfoSizing, Inc.
 20 Kreg Lane
 Manitou Springs, CO 80829

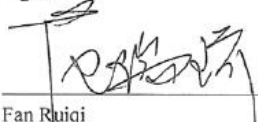
Subject: SPC-1 Letter of Good Faith for the Huawei OceanStor 18500 V3

Huawei Technologies Co., Ltd. is the SPC-1 Test Sponsor for the above listed product. To the best of our knowledge and belief, the required SPC-1 benchmark results and materials we have submitted for that product are complete, accurate, and in full compliance with V3.2 of the SPC-1 benchmark specification.

In addition, we have reported any items in the Benchmark Configuration and execution of the benchmark that affected the reported results even if the items are not explicitly required to be disclosed by the SPC-1 benchmark specification.

Signed:

Date:



 Fan Ruiqi
 President of Storage Product Line

2016.12.27



SPC BENCHMARK 1™

EXECUTIVE SUMMARY

HUAWEI TECHNOLOGIES CO., LTD HUAWEI OCEANSTOR™ 18500 V3

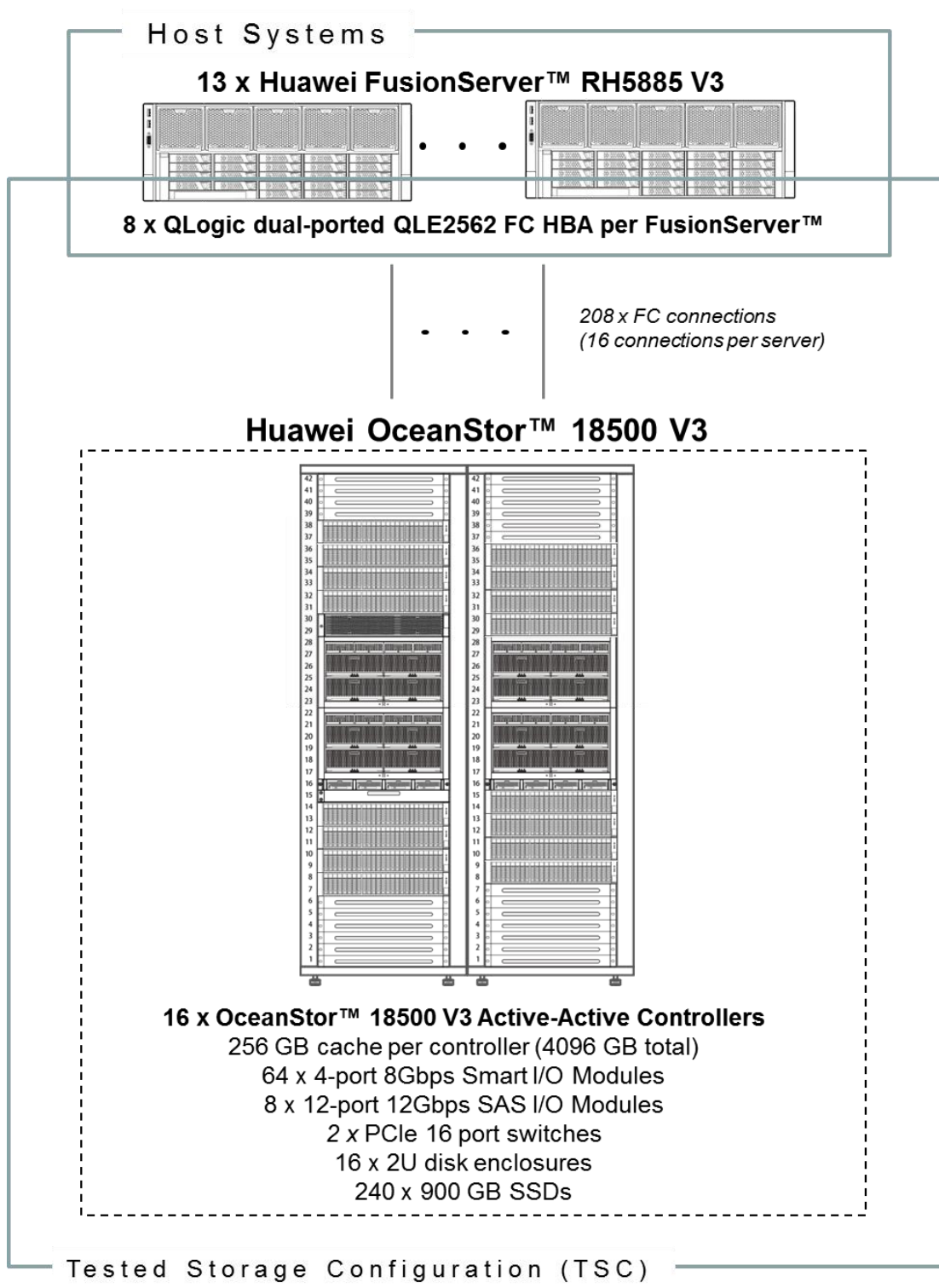
SPC-1 IOPS™	2,340,241
SPC-1 Price-Performance™	\$549.75/SPC-1 KIOPS™
SPC-1 IOPS™ Response Time	0.723 ms
SPC-1 Overall Response Time	0.537 ms
SPC-1 ASU Capacity	76,408 GB
SPC-1 ASU Price	\$16.84/GB
SPC-1 Total System Price	\$1,286,535.26
Data Protection Level	Protected 2 (RAID-10)
Physical Storage Capacity	214,800 GB
Pricing Currency / Target Country	U.S. Dollars / USA

SPC-1 V3.2

SUBMISSION IDENTIFIER: A31003

SUBMITTED FOR REVIEW: DECEMBER 27, 2016

Benchmark Configuration Diagram



Tested Storage Product Description

The OceanStor™ 18000 series storage systems is an optimal choice for mission-critical enterprise applications. The OceanStor™ 18500 and OceanStor™ 18800 have a storage platform designed for next-generation data centers that require virtualization, hybrid cloud, thin IT, and a low carbon footprint.

These enterprise storage solutions are scalable from 2 to 16 controllers and up to 7 PB storage capacity.

This OceanStor™ 18000 series provides critical data storage for finance, government, energy, manufacturing, transport, education, and telecommunication industries.

For more details, visit:

<http://e.huawei.com/en/products/cloud-computing-dc/storage/unified-storage/18000>

Priced Storage Configuration Components

104 x QLogic dual-ported QLE2562 FC HBA
16 x OceanStor™ 18500 V3 Active-Active Controller, each with: 256 GB cache (4096 GB total) 4 x 4-port 8Gbps Smart I/O Module
8 x 12-port 12Gbps SAS I/O Module
16 x 2U disk enclosure, each with: 15 x 900 GB SSD (240 total)
2 x PCIe 16 port switch
1 x Service Processor
1 x 8-port KVM

Storage Configuration Pricing

	Description	Qty	Unit Price	Ext. Price	Disc.	Disc. Price
Hardware & Software						
85V3-4C1TE-AC	OceanStor 18500 V3 Engine (Four Controller, AC240HVDC, 1TB Cache, 16*4 port SmartIO I/O module, 2*12 port 12Gb SAS Entire Sharing I/O module, SPE72C0600) ,Enhanced Version	4	291,029.00	1,164,116.00	72%	325,952.48
LPU5PCIEV3H	2 port PCIe I/O module	16	3,245.00	51,920.00	75%	12,980.00
SSD900-2-H2	900GB SSD SAS Disk Unit(2.5")	240	10,621.00	2,549,040.00	75%	637,260.00
DAE22525U2-H-AC	Disk Enclosure (2U,2.5",AC240HVDC,DAE22525U2)	16	7,032.00	112,512.00	75%	28,128.00
RACK-SYS-H-AC	OceanStor 18000 V3 Series System Cabinet	2	23,672.00	47,344.00	75%	11,836.00
SVP4-V3H	Service Processor (1U, AC240HDVDC,8GB Cache,Including Windows OS Software and Security software)	1	15,042.00	15,042.00	75%	3,760.50
KVM-HIGH-END	KVM,KVM,1U, 17" LED, 8 KVM ports, With Power Cable,1 USB Straight signal cables/With mounting Accessories	1	634.00	634.00	0%	634.00
SWITCH-V3H	PCIe Switch(AC240HVDC,2GB Cache,16 Port,SWE1603P05)	2	6,350.00	12,700.00	75%	3,175.00
OQSFPOM00	Quadwire 40 Gb/s Parallel AOC	32	1,494.00	47,808.00	0%	47,808.00
PDU2000-V3-H	AC Power Distribution Unit	8	127.00	1,016.00	0%	1,016.00
HS-SAS-1-01	High Speed Cable, External MiniSAS HD Cable,1m, (28AWG*4P*2B(S), Indoor use	24	55.00	1,320.00	0%	1,320.00
HS-SAS-3-01	High Speed Cable,Mini SAS HD Cable,3m, (28AWG*4P*2B(S), Indoor use	24	96.00	2,304.00	0%	2,304.00
N8GHBA000	QLOGIC QLE2562 HBA Card, PCIe, 8Gbps DualPort FC Multimode LC Optic Interface	104	1,000.00	104,000.00	0%	104,000.00
VADMSMR02	Software Service, Trend Micro, 05280169,Original Manufacturer Service, 1Year, 7*24 Standard Service, 10 users	2	314.00	628.00	0%	628.00
SN2F01FCPC	Patch Cord,DLC/PC,DLC/PC,Multi-mode, 3m, A1a.2,2mm, OM3 bending insensitive	208	11.00	2,288.00	0%	2,288.00
P-16mm^2-Olivine-LSZH	Power Cable,450V/750V,H07Z-K UL3386, 16mm^2, 107A, LSZH Cable, VDE, UL	10	3.80	38.00	0%	38.00
C3006BK01	Power Cable,600V/1000V,ZA-RVV,3x6mm^2,Black(3Cores:Brown,Blue,Yellow/Green),46A,Outdoor Cable,CE (Unit:meter)	80	6.90	552.00	0%	552.00
85V3-LBASIC-N	Basic Software Suite License(OceanStor OS, DeviceManager ,SmartThin, SmartMotion ,SmartQos, SmartPartition, SmartCache, SmartMigration, SmartErase, SmartMulti-tenant, SystemReporter, Cloud Service)	1	5,631.00	5,631.00	72%	1,576.68
85V3-LBASIC200	Basic Software Suite Capacity License (101-200TB)	200	644.00	128,800.00	72%	36,064.00
85V3-LULTRAPATH	OceanStor UltraPath Software License	1	2,386.00	2,386.00	72%	668.08
Hardware & Software Subtotal						1,221,988.74

Support & Maintenance						
88125ESH	OceanStor 18500 V3 Installation Service - Engineering	1	75,803.64	75,803.64	0.3	53,062.55
88032XSE-88134UHK-36	Basic Software Suite Capacity License(101-200TB)-Hi-Care Application Software Upgrade Support Service-36Month(s)	200	193.05	38,609.40	0.72	10,810.63
88032XUD-88134UHK-36	OceanStor UltraPath Software License-Hi-Care Application Software Upgrade Support Service-36Month(s)	1	715.64	715.64	0.72	200.38
88033JKQ-88134UHK-36	Basic Software Suite License(OceanStor OS, DeviceManager, SmartThin, SmartMotion, SmartQos, SmartPartition, SmartCache, SmartMigration, SmartErase, SmartMulti-tenant, SystemReporter, Cloud Service)-Hi-Care Application Software Upgrade Support Service-36Month(s)	1	1,689.16	1,689.16	0.72	472.96
Support & Maintenance Subtotal						64,546.52
SPC-1 Total System Price						1,286,535.26
SPC-1 IOPS™						2,340,241
SPC-1 Price-Performance™ (\$/SPC-1 KIOPS™)						549.75
SPC-1 ASU Capacity (GB)						76,408
SPC-1 ASU Price (\$/GB)						16.84

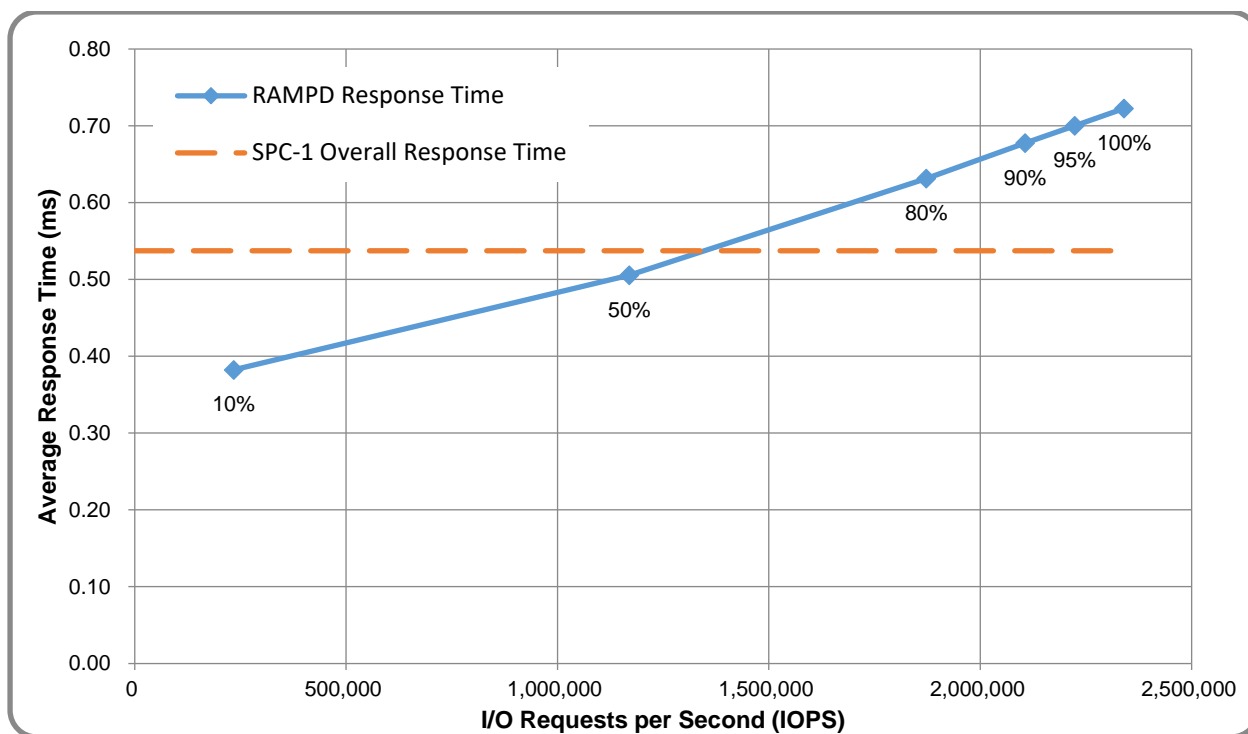
Third-Party Reseller: Huawei Technologies Co., Ltd. only sells its products to third-party resellers who, in turn, sell those products to U.S. customers. The above reflects the pricing quoted by one of those third-party resellers. See Appendix B of the Full Disclosure Report for a copy of the third-party reseller's quotation.

Discount Details: The discounts shown are based on the storage capacity purchased and are generally available.

Warranty: Hi-Care Premier On-Site Service include: 7x24 Technical Assistance Center Access. Access to all new software updates and Online Support. 24x7 with 4-hour On-site Hardware Replacement.

Availability Date: Currently available.

Response Time and Throughput Graph



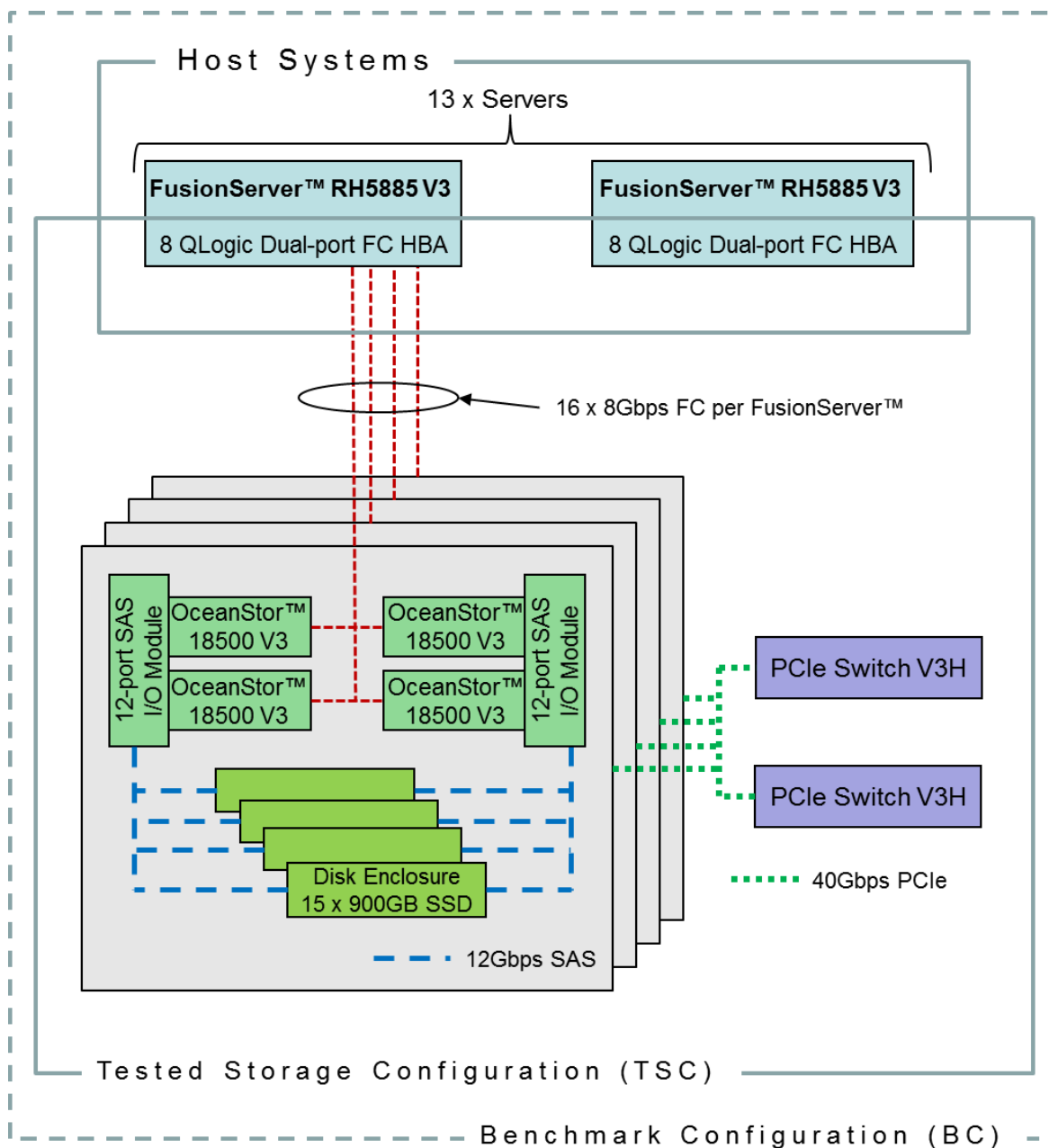
Contact Information	
Test Sponsor Primary Contact	Huawei Technologies Co., Ltd.– www.huawei.com Zhong Xu– xuzhong@huawei.com
SPC Auditor	InfoSizing – www.sizing.com Francois Raab – francois@sizing.com

Revision Information	
SPC Benchmark 1™ Revision	V3.2.0
SPC-1 Workload Generator Revision	V3.0 build d34fb3c
Publication Revision History	<ul style="list-style-type: none"> • First Edition: December 27, 2016 • Second Edition: February 15, 2018 <ul style="list-style-type: none"> - Updated SPC-1 Price-Performance™ metric based on SPC-1 v3.6.0 definition.

CONFIGURATION INFORMATION

Benchmark Configuration and Tested Storage Configuration

The following diagram illustrates the Benchmark Configuration (BC), including the Tested Storage Configuration (TSC) and the Host System(s).



Storage Network Configuration

The Tested Storage Configuration (TSC) involved an external storage subsystem made of 16 Huawei OceanStor 18500, driven by 13 host systems (Huawei FusionServer RH5885 V3). Each FusionServer connected one-to-one to each OceanStor. That connection was established via a port from one of the eight dual-port Fibre Chanel HBAs on the FusionServer; and a port from one of the four 4-port Smart I/O Modules on the OceanStor, leaving 3 of these ports inactive. These Fibre Chanel paths operated at 8Gbps.

Host System and Tested Storage Configuration Components

The following table lists the components of the Host System(s) and the Tested Storage Configuration (TSC).

Host Systems
13 x Huawei FusionServer™ RH5885 V3 4 x Intel Xeon E7-4820 V2 (2.0 GHz 8 Core 16 MB L3) 256 GB Main Memory Red Hat Enterprise Linux 7.1
Priced Storage Configuration
104 x QLogic dual-ported QLE2562 FC HBA
16 x OceanStor™ 18500 V3 Active-Active Controller, each with: 256 GB cache (4096 GB total) 4 x 4-port 8Gbps Smart I/O Module 8 x 12-port 12Gbps SAS I/O Module 16 x 2U disk enclosure, each with: 15 x 900 GB SSD (240 total) 2 x PCIe 16 port switchce 1 x Service Processor 1 x 8-port KVM

Differences Between Tested and Priced Storage Configurations

There were no differences between the Tested Storage Configuration and the Priced Storage Configuration.

Component Changes in Revised Full Disclosure Report

The following table outlines component changes that were made in revisions to this Full Disclosure Report.

Original Component	Revised Component	Description of Change
n/a	n/a	Initial submission

Benchmark Configuration Creation Process

Customer Tuning Parameters and Options

All the customer tuning parameters and options that have been altered from their default values for this benchmark are included in Appendix C and in the Supporting Files (see Appendix A).

Tested Storage Configuration Creation

A detailed description of how the logical representation of the TSC was created is included in Appendix D and in the Supporting Files (see Appendix A).

Tested Storage Configuration Inventory

An inventory of the components in the TSC, as seen by the Benchmark Configuration, is included in Appendix E and in the Supporting Files (see Appendix A).

Workload Generator Storage Configuration

The SPC-1 Workload Generator storage configuration commands and parameters used to invoke the execution of the tests are included in Appendix F and in the Supporting Files (see Appendix A).

Logical Volume Capacity and ASU Mapping

The following table details the capacity of each ASU and how they are mapped to logical volumes (LV).

	LV per ASU	LV Capacity	Used per LV	Total per ASU	% ASU Capacity
ASU-1	18	1,910.2	1,910.2	34,383.4	45.00%
ASU-2	18	1,910.2	1,910.2	34,383.4	45.00%
ASU-3	2	3,820.4	3,820.4	7,640.7	10.00%
SPC-1 ASU Capacity				76,407.5	

Physical Storage Capacity and Utilization

The following table details the Physical Capacity of the storage devices and the Physical Capacity Utilization (percentage of Total Physical Capacity used) in support of hosting the ASUs.

Devices	Count	Physical Capacity	Total Capacity
900GB SSD	240	895.0	214,800.0
Total Physical Capacity			214,800.0
Physical Capacity Utilization			35.57%

Data Protection

The data protection level used for all logical volumes was **Protected 2**, which was accomplished by configuring 16 pools of 15 drives into 16 RAID-10 arrays.

BENCHMARK EXECUTION RESULTS

This portion of the Full Disclosure Report documents the results of the various SPC-1 Tests, Test Phases, and Test Runs.

Benchmark Execution Overview

Workload Generator Input Parameters

The SPC-1 Workload Generator commands and input parameters for the Test Phases are presented in the Supporting Files (see Appendix A).

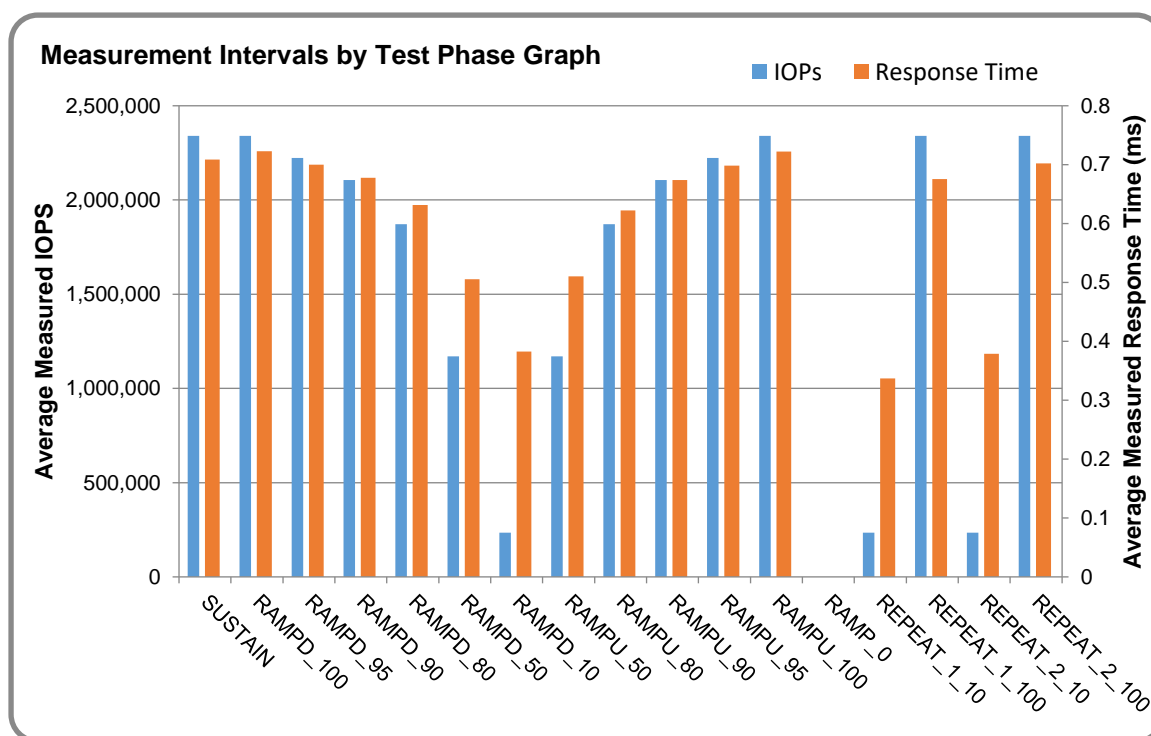
Primary Metrics Test Phases

The benchmark execution consists of the Primary Metrics Test Phases, including the Test Phases SUSTAIN, RAMPD_100 to RAMPD_10, RAMP_50 to RAMP_100, RAMP_0, REPEAT_1 and REPEAT_2.

Each Test Phase starts with a transition period followed by a Measurement Interval.

Measurement Intervals by Test Phase Graph

The following graph presents the average IOPS and the average Response Times measured over the Measurement Interval (MI) of each Test Phase.



Exception and Waiver

None.

SUSTAIN Test Phase

SUSTAIN – Results File

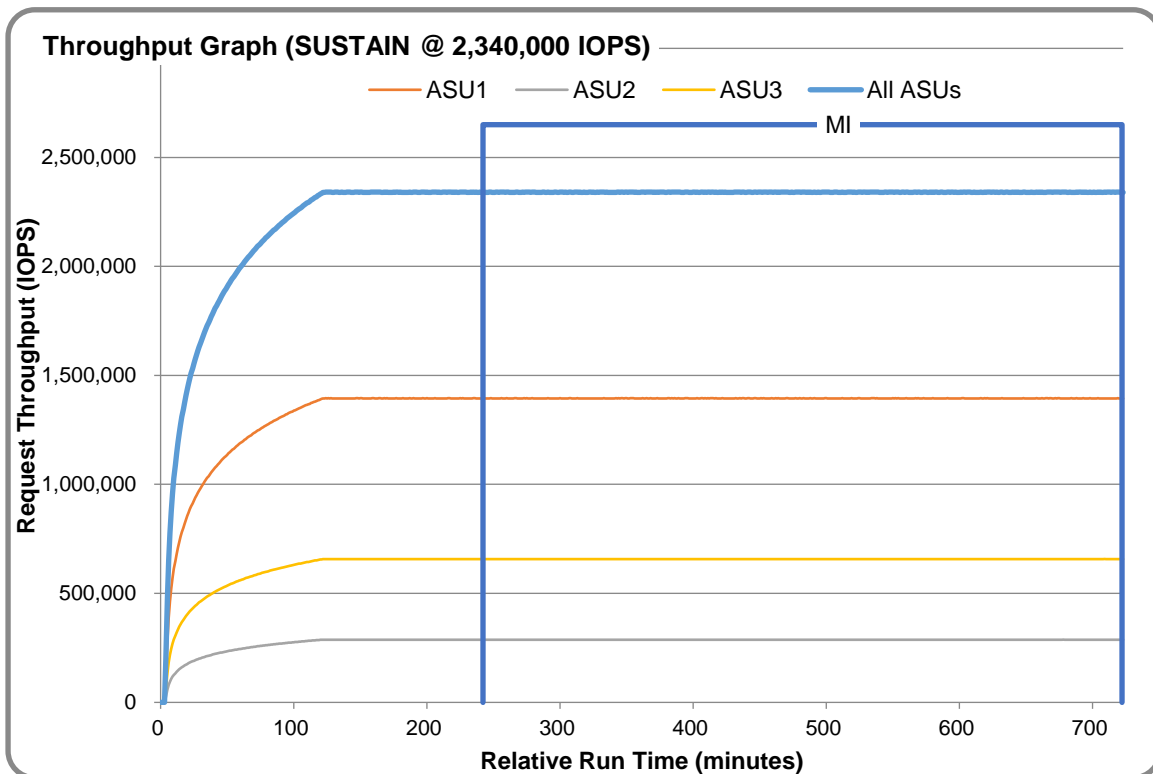
The results file generated during the execution of the SUSTAIN Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

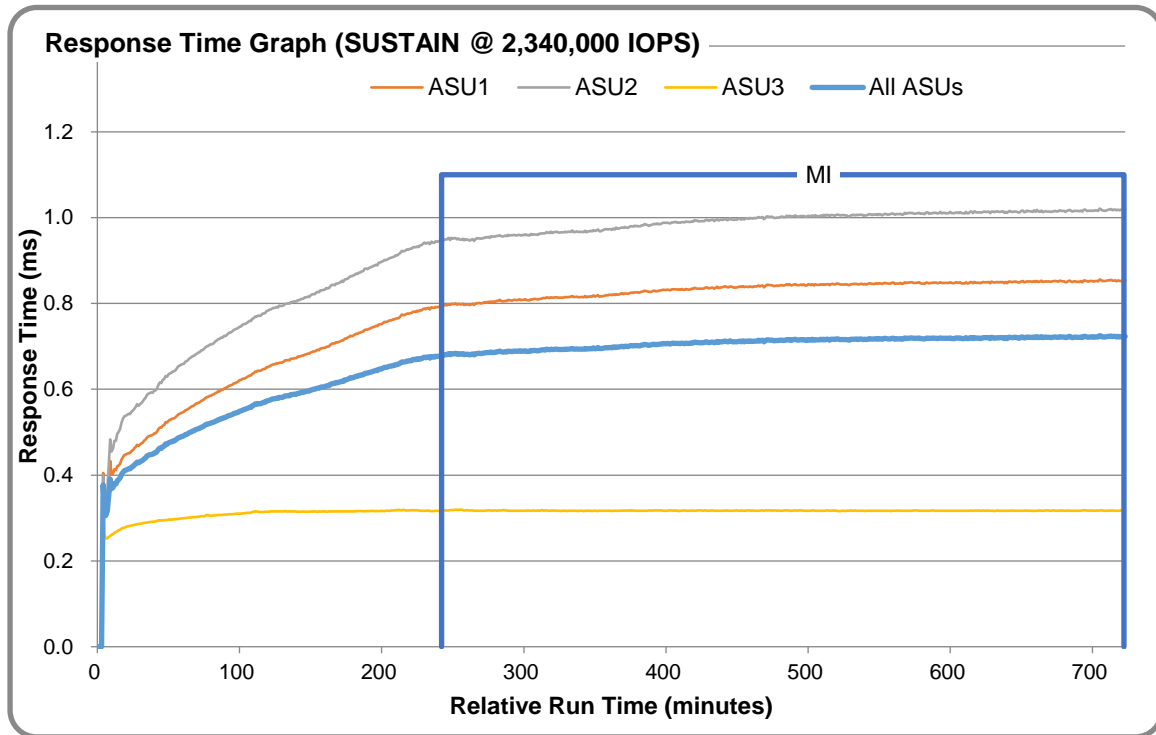
SUSTAIN – Execution Times

Interval	Start Date	Start Time	End Time	Duration
Transition Period	21-Dec-16	18:37:18.246	22:37:18.246	4:00:00.000
Measurement Interval	21-Dec-16	22:37:18.246	6:37:19.246	8:00:01.000

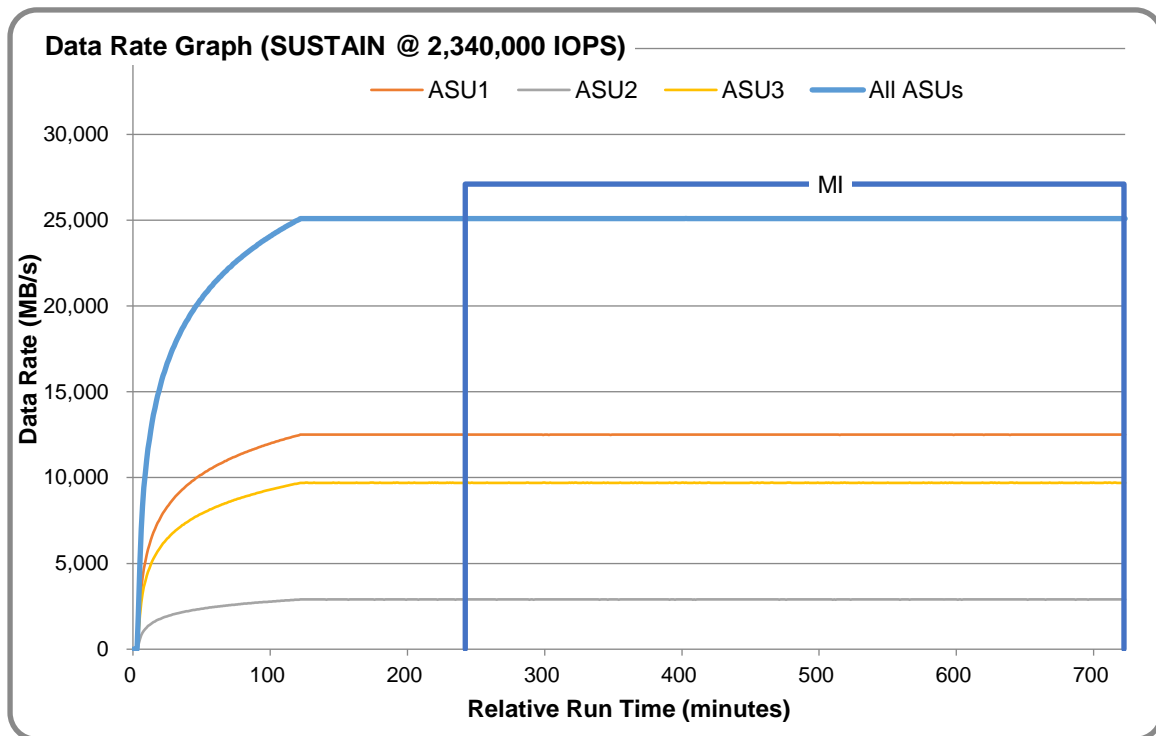
SUSTAIN – Throughput Graph



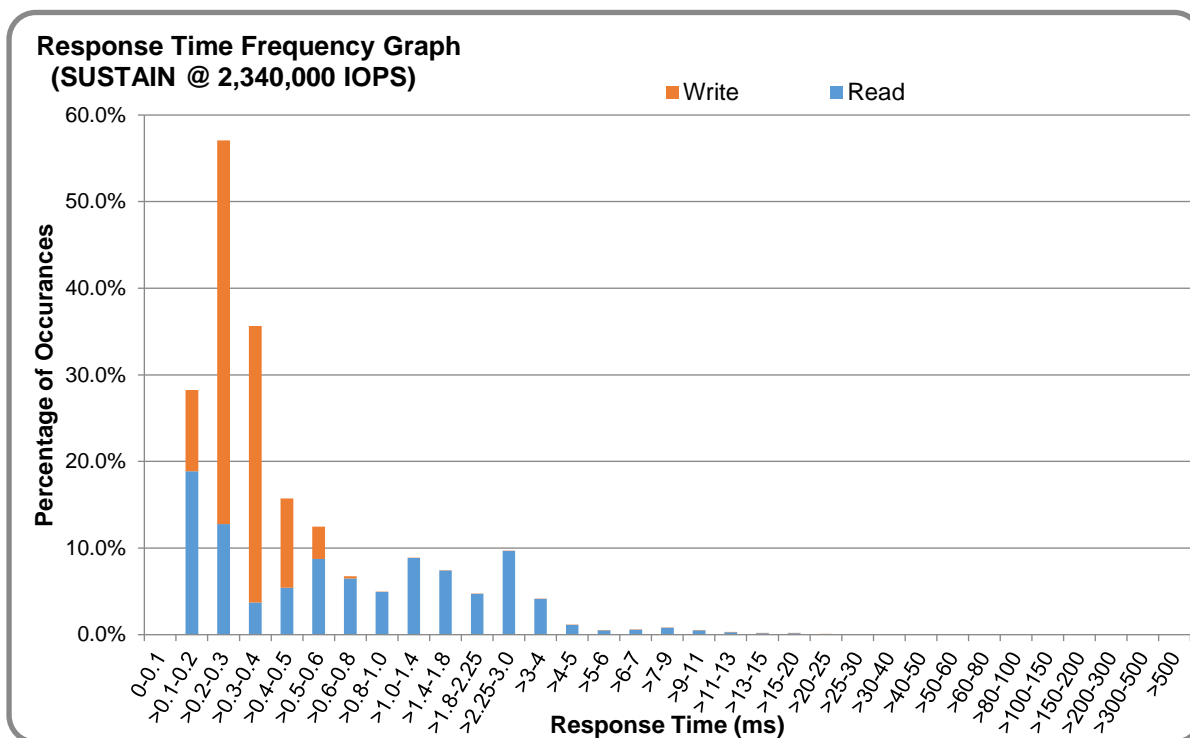
SUSTAIN – Response Time Graph



SUSTAIN – Data Rate Graph



SUSTAIN – Response Time Frequency Graph



SUSTAIN – Intensity Multiplier

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0001	0.0003	0.0002	0.0006	0.0003	0.0005	0.0001
Difference	0.004%	0.002%	0.006%	0.000%	0.000%	0.005%	0.005%	0.002%

RAMPD_100 Test Phase

RAMPD 100 – Results File

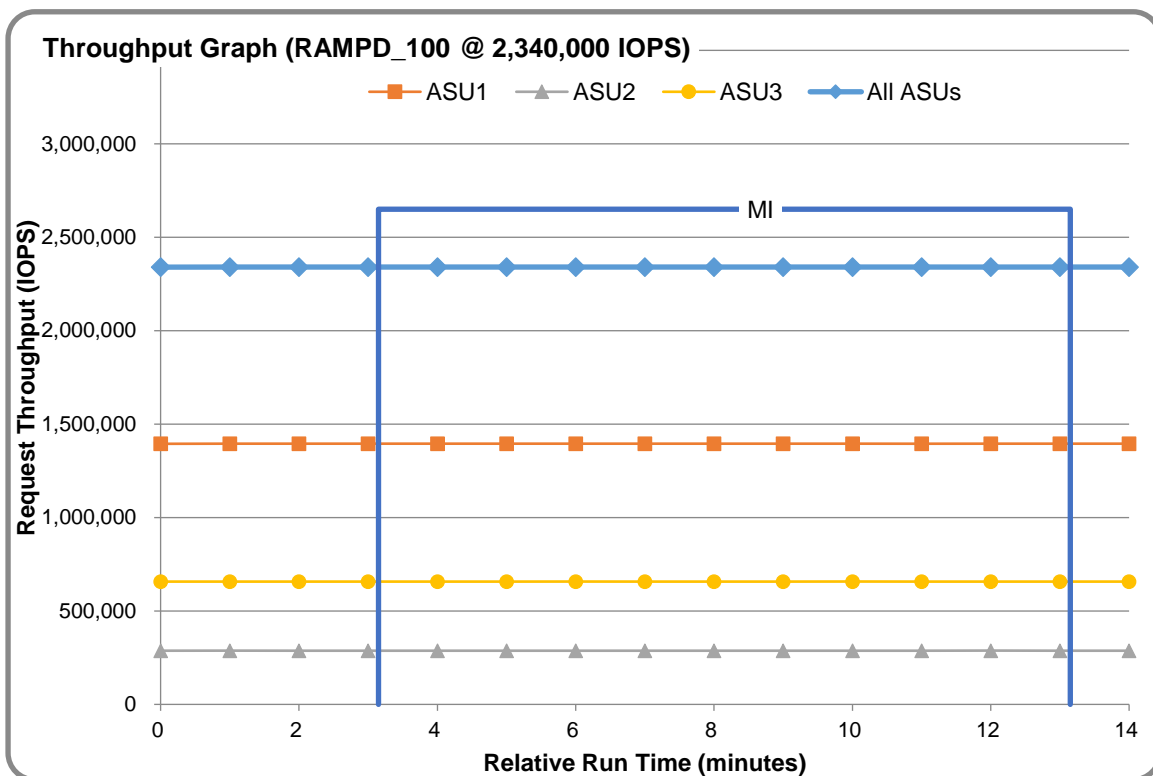
The results file generated during the execution of the RAMPD_100 Test Phase is included in the Supporting Files (see Appendix A) as follows:

- SPC1_METRICS_0_Raw_Results.xlsx

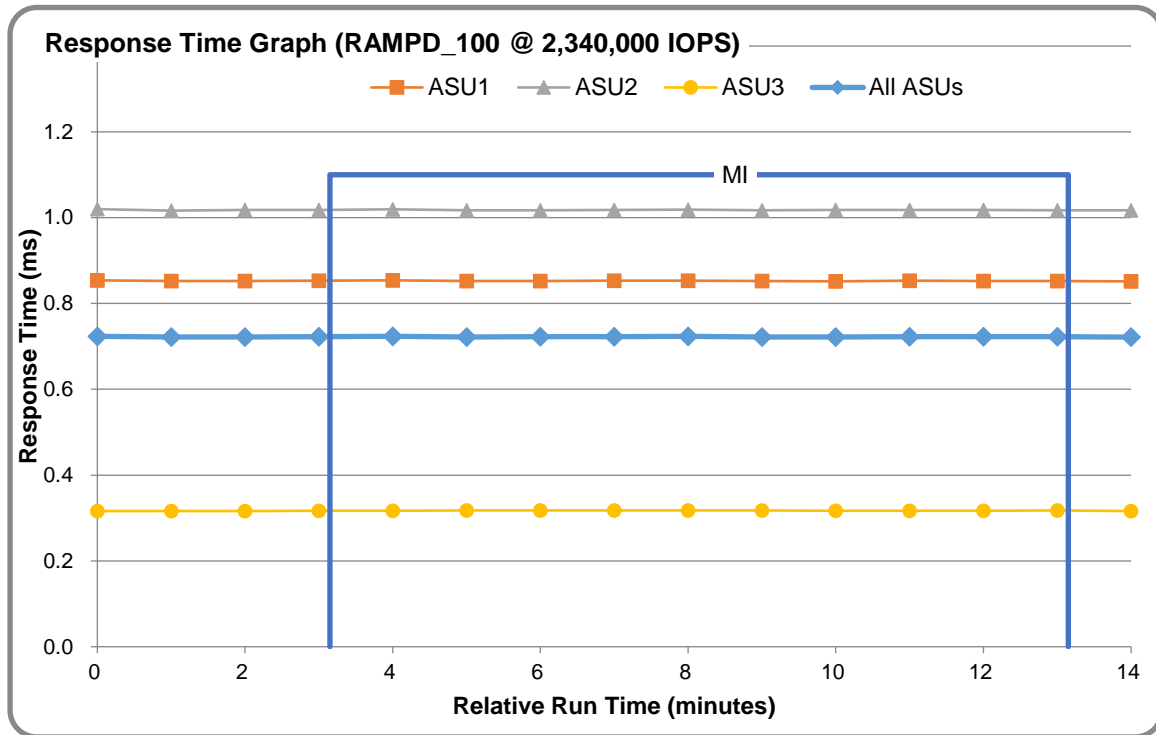
RAMPD 100 – Execution Times

Interval	Start Date	Start Time	End Time	Duration
Transition Period	22-Dec-16	6:38:18.346	6:41:18.346	0:03:00.000
Measurement Interval	22-Dec-16	6:41:18.346	6:51:19.346	0:10:01.000

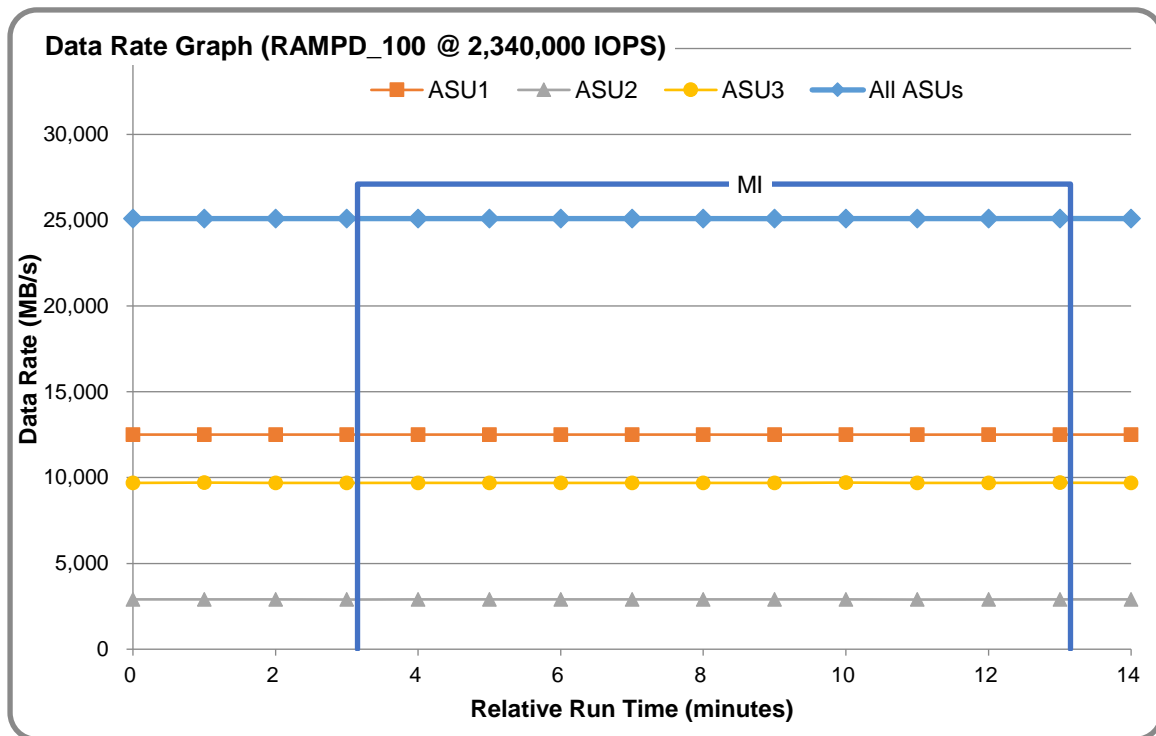
RAMPD 100 – Throughput Graph



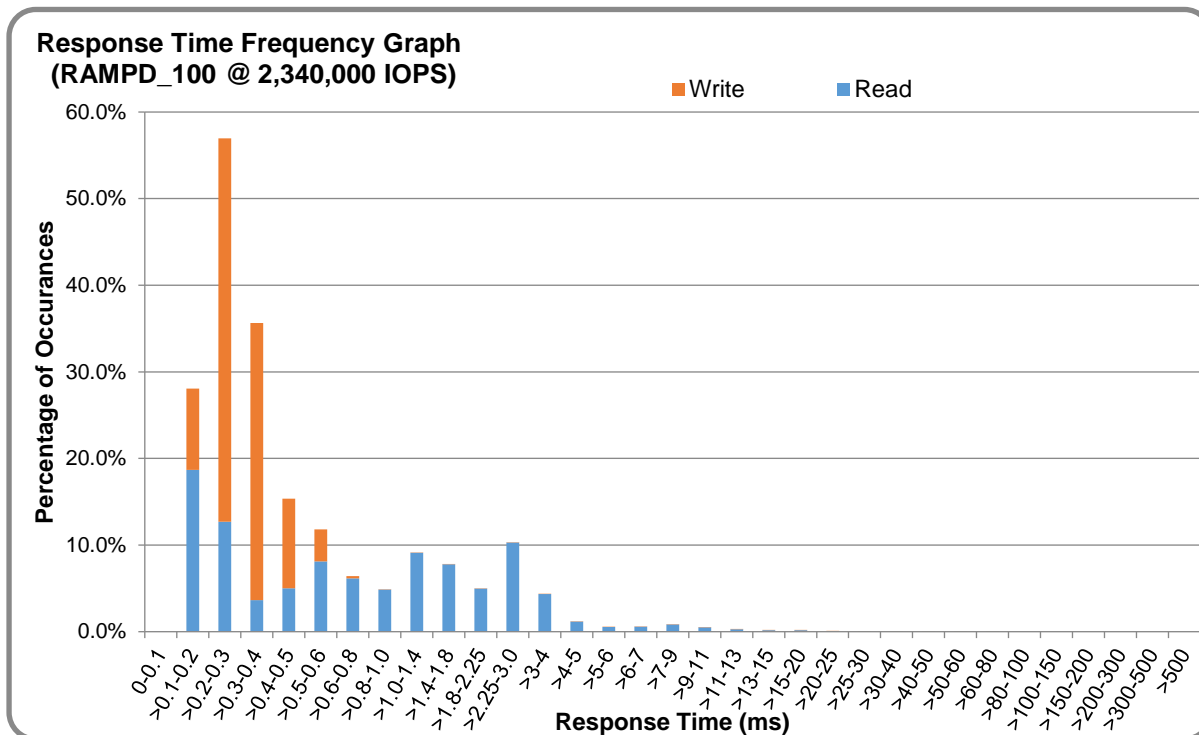
RAMPD 100 – Response Time Graph



RAMPD 100 – Data Rate Graph



RAMPD 100 – Response Time Frequency Graph



RAMPD 100 – Intensity Multiplier

The following table lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percentage of difference (Difference) between Target and Measured.

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0002	0.0002	0.0002	0.0002	0.0007	0.0002	0.0004	0.0001
Difference	0.007%	0.008%	0.015%	0.000%	0.033%	0.012%	0.004%	0.009%

RAMPD 100 – I/O Request Summary

I/O Requests Completed in the Measurement Interval	1,404,139,377
I/O Requests Completed with Response Time <= 30 ms	1,404,048,667
I/O Requests Completed with Response Time > 30 ms	90,710

Response Time Ramp Test

Response Time Ramp Test – Results File

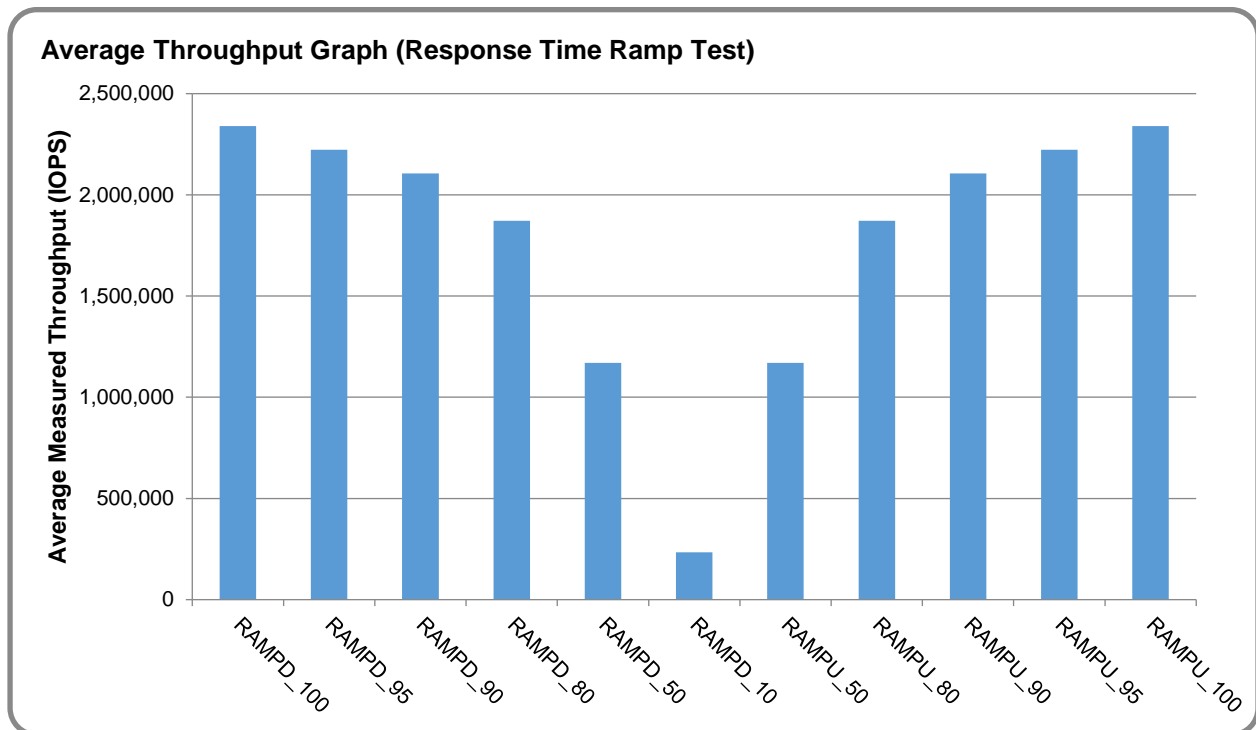
The results file generated during the execution of the Response Time Ramp Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_METRICS_0_Raw_Results.xlsx**

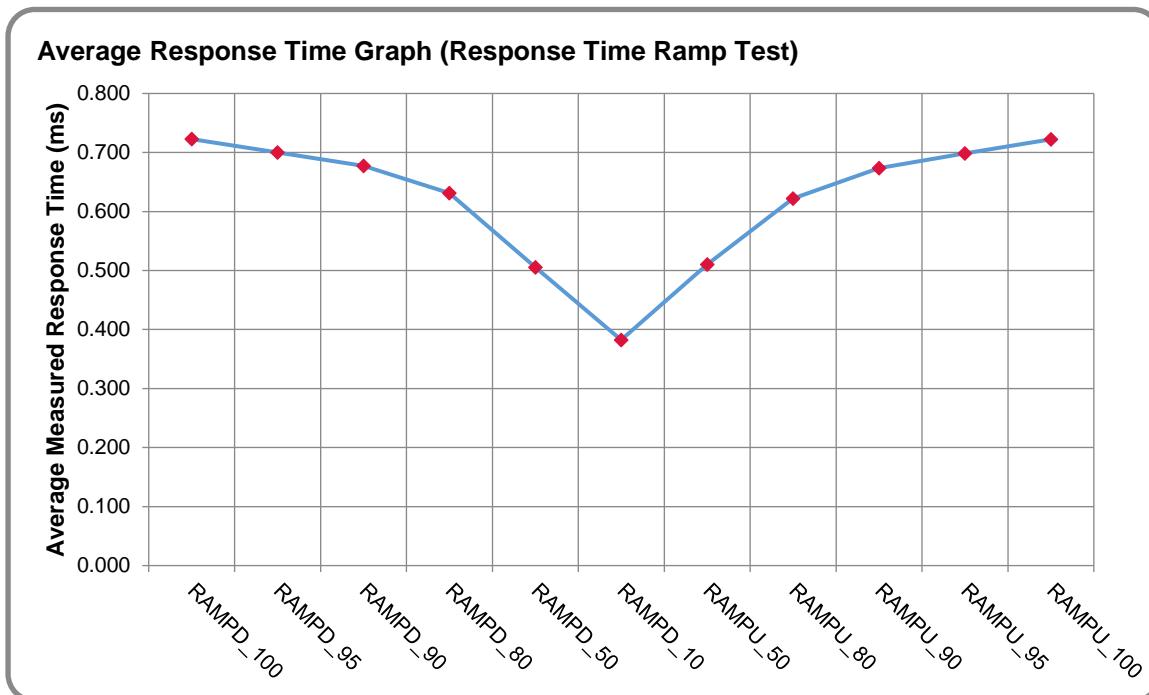
Response Time Ramp Test – Phases

The Response Time Ramp Test is comprised of 11 Test Phases, including six Ramp-Down Phases (executed at 100%, 95%, 90%, 80%, 50%, and 10% of the Business Scaling Unit) and five Ramp-Up Phases (executed at 50%, 80%, 90%, 95%, and 100% of the Business Scaling Unit).

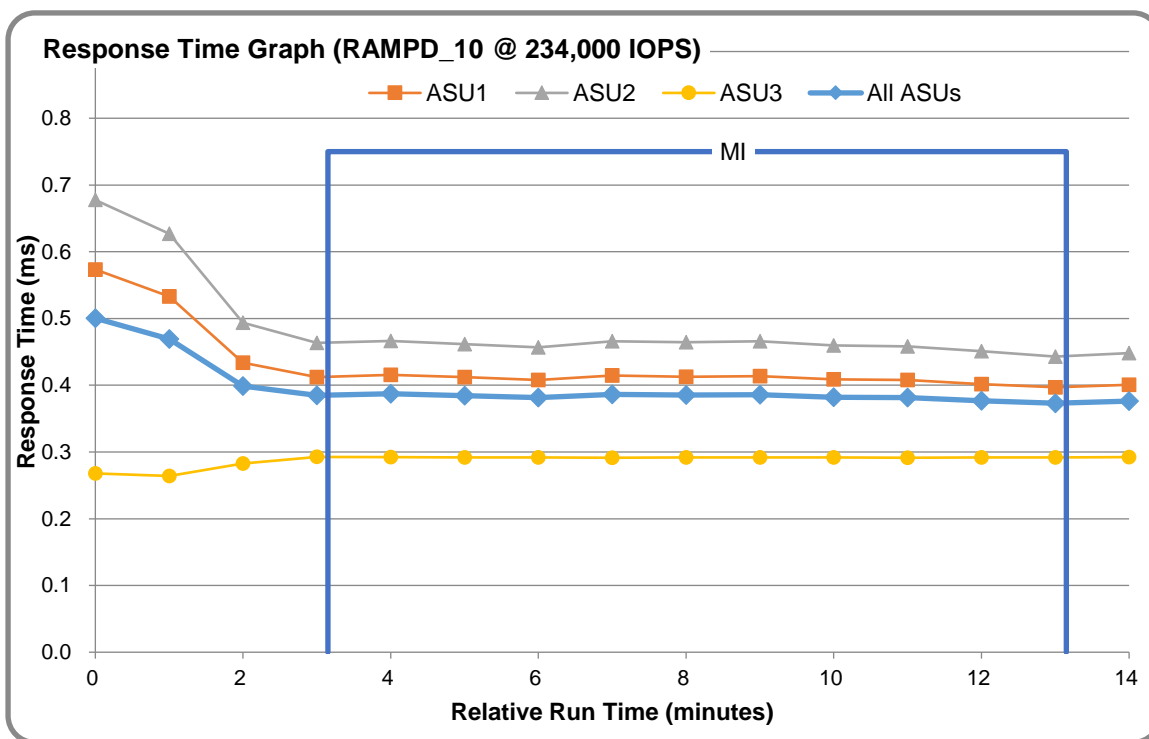
Response Time Ramp Test – Average Throughput Graph



Response Time Ramp Test – Average Response Time Graph



Response Time Ramp Test – RAMPD 10 Response Time Graph



Repeatability Test

Repeatability Test Results File

The results file generated during the execution of the Repeatability Test is included in the Supporting Files (see Appendix A) as follows:

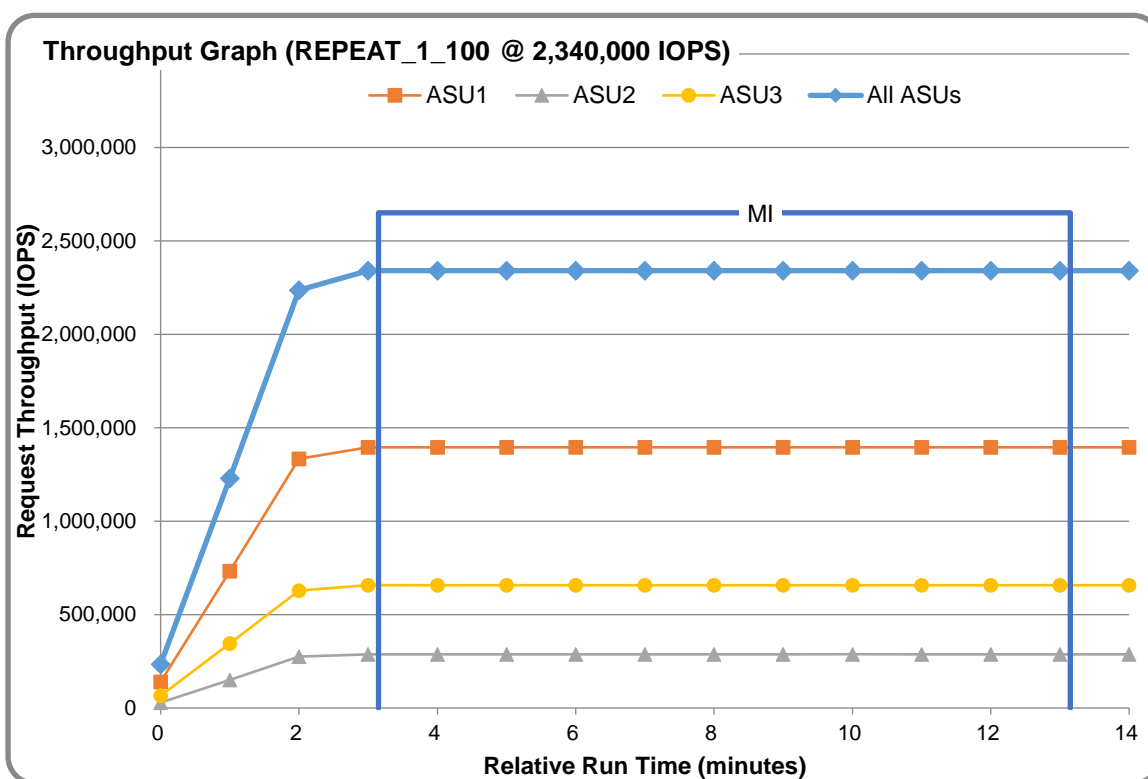
- SPC1_METRICS_0_Raw_Results.xlsx

Repeatability Test Results

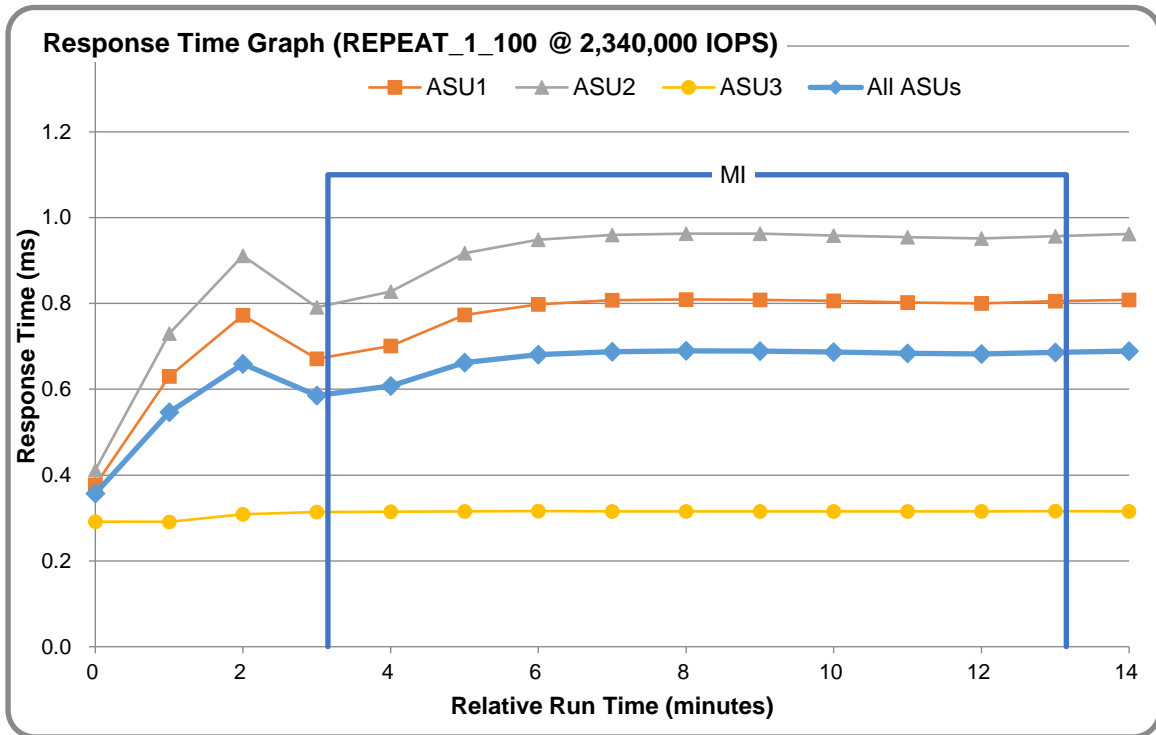
The throughput measurements for the Response Time Ramp Test (RAMPD) and the Repeatability Test Phases (REPEAT_1 and REPEAT_2) are listed in the tables below.

Test Phase	100% IOPS	10% IOPS
RAMPD	2,340,241.7	234,011.0
REPEAT_1	2,340,214.4	233,990.5
REPEAT_2	2,340,110.1	234,007.5

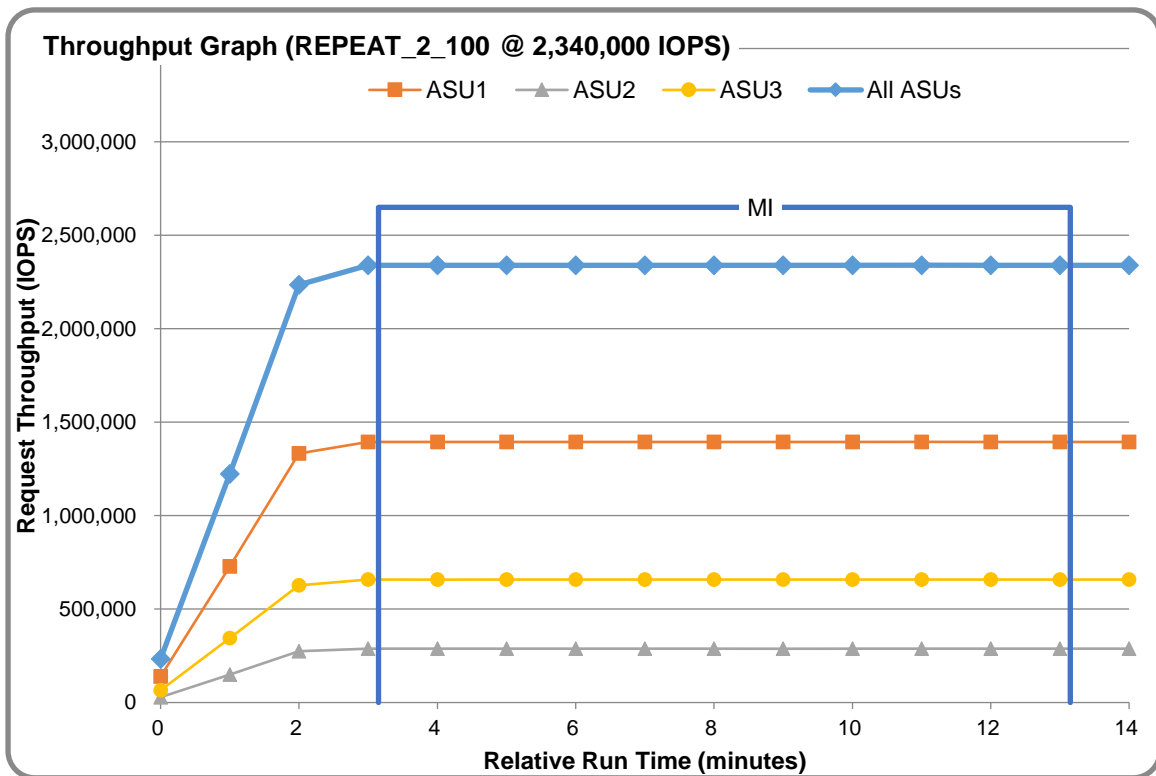
REPEAT 1 100 – Throughput Graph



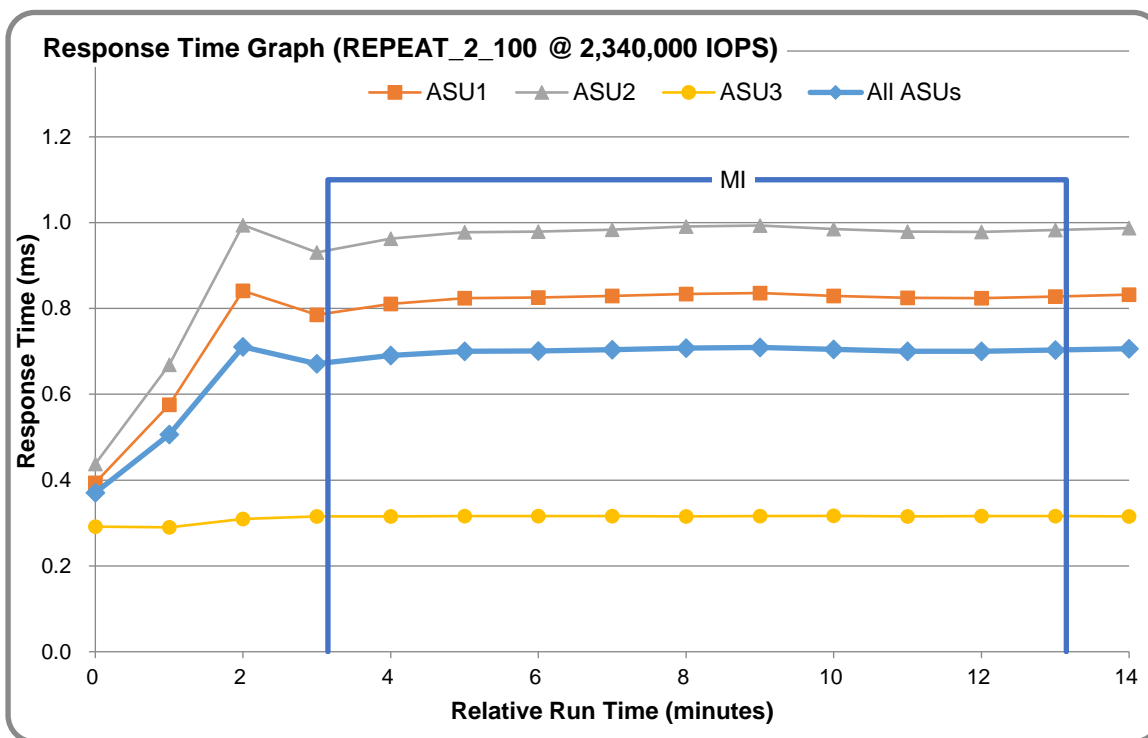
REPEAT 1 100 – Response Time Graph



REPEAT 2 100 – Throughput Graph



REPEAT 2 100 – Response Time Graph



Repeatability Test – Intensity Multiplier

The following tables lists the targeted intensity multiplier (Defined), the measured intensity multiplier (Measured) for each I/O STREAM, its coefficient of variation (Variation) and the percent of difference (Difference) between Target and Measured.

REPEAT_1_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0001	0.0003	0.0001	0.0007	0.0003	0.0004	0.0001
Difference	0.026%	0.004%	0.004%	0.007%	0.021%	0.001%	0.030%	0.004%

REPEAT_2_100 Test Phase

	ASU1-1	ASU1-2	ASU1-3	ASU1-4	ASU2-1	ASU2-2	ASU2-3	ASU3-1
Defined	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Measured	0.0350	0.2810	0.0700	0.2100	0.0180	0.0700	0.0350	0.2810
Variation	0.0004	0.0002	0.0005	0.0001	0.0005	0.0003	0.0005	0.0001
Difference	0.028%	0.005%	0.006%	0.005%	0.000%	0.017%	0.013%	0.002%

Data Persistence Test

Data Persistence Test Results file

The results files generated during the execution of the Data Persistence Test is included in the Supporting Files (see Appendix A) as follows:

- **SPC1_PERSIST_1_0_Raw_Results.xlsx**
- **SPC1_PERSIST_2_0_Raw_Results.xlsx**

Data Persistence Test Execution

The Data Persistence Test was executed using the following sequence of steps:

- The PERSIST_1_0 Test Phase was executed to completion.
- The Benchmark Configuration was taken through an orderly shutdown process and powered off.
- The Benchmark Configuration was powered on and taken through an orderly startup process.
- The PERSIST_2_0 Test Phase was executed to completion.

Data Persistence Test Results

Data Persistence Test Phase: Persist1	
Total Number of Logical Blocks Written	289,423,687
Total Number of Logical Blocks Verified	144,452,449
Total Number of Logical Blocks that Failed Verification	0
Time Duration for Writing Test Logical Blocks (sec.)	301
Size in bytes of each Logical Block	8,192
Number of Failed I/O Requests in the process of the Test	0

APPENDIX A: SUPPORTING FILES

The following table details the content of the Supporting Files provided as part of this Full Disclosure Report.

File Name	Description	Location
/SPC1_RESULTS	Data reduction worksheets	root
SPC1_INIT_0_Raw_Results.xlsx	Raw results for INIT Test Phase	/SPC1_RESULTS
SPC1_METRICS_0_Quick_Look.xlsx	Quick Look Test Run Overview	/SPC1_RESULTS
SPC1_METRICS_0_Raw_Results.xlsx	Raw results for Primary Metrics Test	/SPC1_RESULTS
SPC1_METRICS_0_Summary_Results.xlsx	Primary Metrics Summary	/SPC1_RESULTS
SPC1_PERSIST_1_0_Raw_Results.xlsx	Raw results for PERSIST1 Test Phase	/SPC1_RESULTS
SPC1_PERSIST_2_0_Raw_Results.xlsx	Raw results for PERSIST2 Test Phase	/SPC1_RESULTS
SPC1_Run_Set_Overview.xlsx	Run Set Overview Worksheet	/SPC1_RESULTS
SPC1_VERIFY_0_Raw_Results.xlsx	Raw results for first VERIFY Test Phase	/SPC1_RESULTS
SPC1_VERIFY_1_Raw_Results.xlsx	Raw results for second VERIFY Test Phase	/SPC1_RESULTS
/C_Tuning	Tuning parameters and options	root
aio-max-nr.sh	Set maximum asynchronous I/O	/C_Tuning
nr_requests.sh	Increase disk queue depth	/C_Tuning
scheduler.sh	Change the I/O scheduler	/C_Tuning
/D_Creation	Storage configuration creation	root
mklun.txt	Create the storage environment	/D_Creation
mkvolume.sh	Create the Logical Volumes	/D_Creation
/E_Inventory	Configuration inventory	root
shstorage.tcl	Captures profile of storage environment	/E_Inventory
profile1_volume.log	List of logical volumes before INIT	/E_Inventory
profile1_storage.log	List of storage devices before INIT	/E_Inventory
profile2_volume.log	List of logical volumes after restart	/E_Inventory
profile2_storage.log	List of storage devices after restart	/E_Inventory
/F_Generator	Workload generator	root
slave_asu.asu	Defining LUNs hosting the ASUs	/F_generator
13host.HST	Host configuration file	/F_generator
full_run.sh	Executing all test phases	/F_generator

APPENDIX B: THIRD PARTY QUOTATION



Address: 32 Broadway, Suite 401
 New York, NY 10004
 Tel: 212-809-6625
 Email: sales@noviant.com

11/26/2016, Quote Valid:90 Days

No.	Model	Description	Qty.	Unit Price (USD)	Ext Price (USD)	Disc. (off)	Disc. Price (USD)
1	Phase						
1.1	Location						
1.1.1	OceanStor 18500 V3 Storage System						
1.1.1.1	Engine						
	85V3-4C1TE-AC	OceanStor 18500 V3 Engine(Four Controller,AC/240HVDC,1TB Cache,16*4 port SmartIO I/O module,2*12 port 12Gb SAS Entire Sharing I/O module,SPE72C0600),Enhanced Version	4	291,029.00	1164116	72%	325952.48
1.1.2	Expand Interface Module						
	LPU5PCIEV3H	2 port PCIe I/O module	16	3,245.00	51920	75%	12980.00
1.1.3	Disk Components						
	SSD900-2-H2	900GB SSD SAS Disk Unit(2.5")	240	10,621.00	2549040	75%	637280.00
1.1.4	Disk Enclosure						
	DAE2252U2-H-AC	Disk Enclosure(2U,2.5",AC/240HVDC,DAE2252 5U2)	16	7,032.00	112512	75%	28128.00
1.1.5	Cabinet						
	RACK-SYS-H-AC	OceanStor 18000 V3 Series System Cabinet	2	23,672.00	47344	75%	11836.00
1.1.6	Option Class Item						
	SVP4-V3H	Service Processor (1U, AC/240HVDC,8GB Cache,including Windows OS Software and Security software)	1	15,042.00	15042	75%	3780.50
	KVM-HIGH-END	KVM,KVM,1U, 17" LED, 8 KVM ports, With Power Cable,1 USB Straight signal cables/With mounting Accessories,High-end Storage only,Chinese and English) doc.black,Compliant	1	634.00	634	0%	634.00
	SWITCH-V3H	PCIe Switch(AC/240HVDC,2GB Cache,16 Port,SWE1603P05)	2	6,350.00	12700	75%	3175.00
	QOSFPOM00	Quadwire 40 Gb/s Parallel AOC	32	1,494.00	47808	0%	47808.00
	PDU2000-V3-H	AC Power Distribution Unit	8	127.00	1016	0%	1016.00
	HS-SAS-1-01	High Speed Cable,External MiniSAS HD Cable,1m,(SFF 8644 Plug),(28AWG*4P*2B(S)),(SFF 8644 Plug),Indoor use	24	55.00	1320	0%	1320.00
	HS-SAS-3-01	High Speed Cable,Mini SAS HD Cable,3m,(SFF 8644 Plug),(28AWG*4P*2B(S)),(SFF 8644 Plug),Indoor use	24	96	2304	0%	2304.00
1.1.7	HBA						
	N8GHBA000	QLOGIC QLE2582 HBA Card,PCIe,8Gbps DualPort ,Fiber Channel Multimode LC Optic Interface,English Manual, No Drive CD	104	1000.00	104000	0%	104000.00

kw



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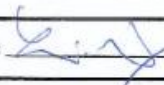
No.	Model	Description	Qty.	Unit Price (USD)	Ext. Price (USD)	Disc. (off)	Disc. Price (USD)
1.1.8 Accessory							
	VADMSMR02	Software Service,Trend Micro,05280169,Original Manufacturer Service, 1 Year,7*24 Standard Service,10 users	2	314.00	628	0%	628.00
	SN2F01FCPC	Patch Cord,DLC/PC,DLC/PC,Multi-mode,3m,A1a,2.2mm,OM3 bending insensitive	208	11.00	2288	0%	2288.00
	P-16mm*2-Olive-LSZH	Power Cable,450V/750V,H07Z-K UL3386,16mm*2, Yellow/Green,107A,LSZH Cable,VDE,UL (Unit:meter)	10	3.80	38	0%	38.00
	C3006BK01	Power Cable,600V/1000V ZA-RVV,3x6mm*2,Black(3Cores Brown,Blue,Yellow/Green),46A,Outdoor Cable,CE (Unit:meter)	80	6.90	552	0%	552.00
1.1.9 Storage Software							
	85V3-LBASIC-N	Basic Software Suite License(OceanStor OS,DeviceManager,SmartThin,SmartMotion,SmartQos,SmartPartition,SmartCache,SmartMigration,SmartErase,SmartMulti-tenant,SystemReporter,Cloud Service)	1	5,631.00	5631	72%	1576.68
	85V3-LBASIC200	Basic Software Suite Capacity License(101-200TB)	200	644.00	128800	72%	36064.00
	85V3-LULTRAPATH	OceanStor UltraPath Software License	1	2,386.00	2386	72%	688.08
Total of Product							1,221,988.74
1.1.10 Maintenance Support Service							
	88125ESH	OceanStor 18500 V3 Installation Service - Engineering	1	75,803.64	75804	30%	53062.55
	88032XSE-88134UHK-36	Basic Software Suite Capacity License(101-200TB)-Hi-Care Application Software Upgrade Support Service-36Month(s)	200	193.05	38609	72%	10810.63
	88032XUD-88134UHK-36	OceanStor UltraPath Software License-Hi-Care Application Software Upgrade Support Service-36Month(s)	1	715.04	716	72%	200.38
	88033JKQ-88134UHK-36	Basic Software Suite License(OceanStor OS,DeviceManager,SmartThin,SmartMotion,SmartQos,SmartPartition,SmartCache,SmartMigration,SmartErase,SmartMulti-tenant,SystemReporter,Cloud Service)-Hi-Care Application Software Upgrade Support Service-36Month(s)	1	1,689.16	1689	72%	472.98
Total of Service (3 years)							64,546.52
Total Price							1,286,535.26
Notes Hi-Care Premier On-Site Service include: 7*24 Technical Assistance Center Access, Access to all new software updates and Online Support, 24*7*4 Hours Onsite Hardware Replacement.							

h.w.



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 Email: sales@noviant.com

11/26/2016, Quote Valid:90 Days

No.	Model	Description	Qty.	Unit Price (USD)	Ext. Price (USD)	Disc. (off)	Disc. Price (USD)
Payment Terms:							
Comments:							
<p>Noviant is an Authorized Huawei Value Added reseller (VAR) of networking and IT products. Products sold by Noviant are factory new unless otherwise specified. All new products sold by Noviant carry its own Original Equipment Manufacturer's (OEM) Limited Warranty and software licenses. This Quote is valid for 90 days. Prices and availability is subject to change without notice. Installation and configuration costs are not included in the quoted pricing unless specified. A 20% Restocking Fee applies to all cancelled orders and/or returned products. Special Orders are non-returnable. Buyer is responsible for payment of all applicable taxes and freight charges. Issuance of customer PO against this Quote constitutes acceptance of Noviant Sales Terms conditions.</p>							
I agree to the these terms and conditions.							
Authorized Acceptance: _____ Print Name: _____ Date: _____							
Noviant:  Print Name: <u>Kevin Wang</u> Date: <u>12/2/16</u>							

APPENDIX C: TUNING PARAMETERS AND OPTIONS

The following scripts, listed below, were used to set tuning parameters and options:

- ***aio-max-nr.sh*** to set the maximum asynchronous I/O
- ***nr_requests.sh*** to change the I/O scheduler
- ***scheduler.sh*** to increase the disk queue depth

The scripts described above are included in the Supporting Files (see Appendix A) and listed below.

aio-max-nr.sh

```
echo 1048576 > /proc/sys/fs/aio-max-nr
```

nr_requests.sh

```
echo 1024 > /sys/block/sdb/queue/nr_requests  
echo 1024 > /sys/block/sdc/queue/nr_requests  
echo 1024 > /sys/block/sdd/queue/nr_requests  
echo 1024 > /sys/block/sde/queue/nr_requests  
echo 1024 > /sys/block/sdf/queue/nr_requests  
echo 1024 > /sys/block/sdg/queue/nr_requests  
echo 1024 > /sys/block/sdh/queue/nr_requests  
echo 1024 > /sys/block/sdi/queue/nr_requests  
echo 1024 > /sys/block/sdj/queue/nr_requests  
echo 1024 > /sys/block/sdk/queue/nr_requests  
echo 1024 > /sys/block/sdl/queue/nr_requests  
echo 1024 > /sys/block/sdm/queue/nr_requests  
echo 1024 > /sys/block/sdn/queue/nr_requests  
echo 1024 > /sys/block/sdo/queue/nr_requests  
echo 1024 > /sys/block/sdp/queue/nr_requests  
echo 1024 > /sys/block/sdq/queue/nr_requests  
echo 1024 > /sys/block/sdr/queue/nr_requests  
echo 1024 > /sys/block/sds/queue/nr_requests  
echo 1024 > /sys/block/sdt/queue/nr_requests  
echo 1024 > /sys/block/sdu/queue/nr_requests  
echo 1024 > /sys/block/sdv/queue/nr_requests  
echo 1024 > /sys/block/sdw/queue/nr_requests  
echo 1024 > /sys/block/sdx/queue/nr_requests  
echo 1024 > /sys/block/sdy/queue/nr_requests  
echo 1024 > /sys/block/sdz/queue/nr_requests  
echo 1024 > /sys/block/sdaa/queue/nr_requests  
echo 1024 > /sys/block/sdab/queue/nr_requests  
echo 1024 > /sys/block/sdac/queue/nr_requests  
echo 1024 > /sys/block/sdad/queue/nr_requests  
echo 1024 > /sys/block/sdae/queue/nr_requests  
echo 1024 > /sys/block/sdaf/queue/nr_requests  
echo 1024 > /sys/block/sdag/queue/nr_requests
```

scheduler.sh

```
echo noop > /sys/block/sdb/queue/scheduler
echo noop > /sys/block/sdc/queue/scheduler
echo noop > /sys/block/sdd/queue/scheduler
echo noop > /sys/block/sde/queue/scheduler
echo noop > /sys/block/sdf/queue/scheduler
echo noop > /sys/block/sdg/queue/scheduler
echo noop > /sys/block/sdh/queue/scheduler
echo noop > /sys/block/sdi/queue/scheduler
echo noop > /sys/block/sdj/queue/scheduler
echo noop > /sys/block/sdk/queue/scheduler
echo noop > /sys/block/sdl/queue/scheduler
echo noop > /sys/block/sdm/queue/scheduler
echo noop > /sys/block/sdn/queue/scheduler
echo noop > /sys/block/sdo/queue/scheduler
echo noop > /sys/block/sdp/queue/scheduler
echo noop > /sys/block/sdq/queue/scheduler
echo noop > /sys/block/sdr/queue/scheduler
echo noop > /sys/block/sds/queue/scheduler
echo noop > /sys/block/sdt/queue/scheduler
echo noop > /sys/block/sdu/queue/scheduler
echo noop > /sys/block/sdv/queue/scheduler
echo noop > /sys/block/sdw/queue/scheduler
echo noop > /sys/block/sdx/queue/scheduler
echo noop > /sys/block/sdy/queue/scheduler
echo noop > /sys/block/sdz/queue/scheduler
echo noop > /sys/block/sdaa/queue/scheduler
echo noop > /sys/block/sdab/queue/scheduler
echo noop > /sys/block/sdac/queue/scheduler
echo noop > /sys/block/sdad/queue/scheduler
echo noop > /sys/block/sdae/queue/scheduler
echo noop > /sys/block/sdaf/queue/scheduler
echo noop > /sys/block/sdag/queue/scheduler
```

APPENDIX D: STORAGE CONFIGURATION CREATION

Environment

First, the CLI commands from the following command file are copied from the file and pasted into the OceanStor 18500 V3 CLI window. These commands are executed on one of the Host Systems.

- ***mklnun.txt***

Next, the following shell script is executed on one of the Host Systems.

- ***mkvolume.sh***

Step 1 - Create Disk Domains, Storage Pools, LUNs

The ***mklnun.txt*** command file, listed below, includes all the CLI commands to perform the following actions:

- Create 16 disk domains
- Create 16 storage pools
- Create 32 LUNs
- Create one LUN group
- Add the 32 LUNs to the LUN group

The command file described above is included in the Supporting Files (see Appendix A) and listed below.

mklnun.txt

```
create disk_domain name=1 disk_list=DAE000.0-14 disk_domain_id=1
create disk_domain name=2 disk_list=DAE010.0-14 disk_domain_id=2
create disk_domain name=3 disk_list=DAE020.0-14 disk_domain_id=3
create disk_domain name=4 disk_list=DAE030.0-14 disk_domain_id=4
create disk_domain name=5 disk_list=DAE100.0-14 disk_domain_id=5
create disk_domain name=6 disk_list=DAE110.0-14 disk_domain_id=6
create disk_domain name=7 disk_list=DAE120.0-14 disk_domain_id=7
create disk_domain name=8 disk_list=DAE130.0-14 disk_domain_id=8
create disk_domain name=9 disk_list=DAE200.0-14 disk_domain_id=9
create disk_domain name=10 disk_list=DAE210.0-14 disk_domain_id=10
create disk_domain name=11 disk_list=DAE220.0-14 disk_domain_id=11
create disk_domain name=12 disk_list=DAE230.0-14 disk_domain_id=12
create disk_domain name=13 disk_list=DAE300.0-14 disk_domain_id=13
create disk_domain name=14 disk_list=DAE310.0-14 disk_domain_id=14
create disk_domain name=15 disk_list=DAE320.0-14 disk_domain_id=15
create disk_domain name=16 disk_list=DAE330.0-14 disk_domain_id=16

-----

create storage_pool name=pool1 disk_type=SSD capacity=4500GB disk_domain_id=1
  stripe_depth=32KB raid_level=RAID10 pool_id=1
create storage_pool name=pool2 disk_type=SSD capacity=4500GB disk_domain_id=2
  stripe_depth=32KB raid_level=RAID10 pool_id=2
create storage_pool name=pool3 disk_type=SSD capacity=4500GB disk_domain_id=3
  stripe_depth=32KB raid_level=RAID10 pool_id=3
```

```
create storage_pool name=pool4 disk_type=SSD capacity=4500GB disk_domain_id=4
  stripe_depth=32KB raid_level=RAID10 pool_id=4
create storage_pool name=pool5 disk_type=SSD capacity=4500GB disk_domain_id=5
  stripe_depth=32KB raid_level=RAID10 pool_id=5
create storage_pool name=pool6 disk_type=SSD capacity=4500GB disk_domain_id=6
  stripe_depth=32KB raid_level=RAID10 pool_id=6
create storage_pool name=pool7 disk_type=SSD capacity=4500GB disk_domain_id=7
  stripe_depth=32KB raid_level=RAID10 pool_id=7
create storage_pool name=pool8 disk_type=SSD capacity=4500GB disk_domain_id=8
  stripe_depth=32KB raid_level=RAID10 pool_id=8
create storage_pool name=pool9 disk_type=SSD capacity=4500GB disk_domain_id=9
  stripe_depth=32KB raid_level=RAID10 pool_id=9
create storage_pool name=pool10 disk_type=SSD capacity=4500GB disk_domain_id=10
  stripe_depth=32KB raid_level=RAID10 pool_id=10
create storage_pool name=pool11 disk_type=SSD capacity=4500GB disk_domain_id=11
  stripe_depth=32KB raid_level=RAID10 pool_id=11
create storage_pool name=pool12 disk_type=SSD capacity=4500GB disk_domain_id=12
  stripe_depth=32KB raid_level=RAID10 pool_id=12
create storage_pool name=pool13 disk_type=SSD capacity=4500GB disk_domain_id=13
  stripe_depth=32KB raid_level=RAID10 pool_id=13
create storage_pool name=pool14 disk_type=SSD capacity=4500GB disk_domain_id=14
  stripe_depth=32KB raid_level=RAID10 pool_id=14
create storage_pool name=pool15 disk_type=SSD capacity=4500GB disk_domain_id=15
  stripe_depth=32KB raid_level=RAID10 pool_id=15
create storage_pool name=pool16 disk_type=SSD capacity=4500GB disk_domain_id=16
  stripe_depth=32KB raid_level=RAID10 pool_id=16
```

```
-----
create lun name=lun1 pool_id=1 capacity=2248GB owner_controller=0A lun_id=1
create lun name=lun2 pool_id=1 capacity=2248GB owner_controller=0B lun_id=2
create lun name=lun3 pool_id=2 capacity=2248GB owner_controller=0C lun_id=3
create lun name=lun4 pool_id=2 capacity=2248GB owner_controller=0D lun_id=4
create lun name=lun5 pool_id=3 capacity=2248GB owner_controller=0C lun_id=5
create lun name=lun6 pool_id=3 capacity=2248GB owner_controller=0D lun_id=6
create lun name=lun7 pool_id=4 capacity=2248GB owner_controller=0A lun_id=7
create lun name=lun8 pool_id=4 capacity=2248GB owner_controller=0B lun_id=8

create lun name=lun9 pool_id=5 capacity=2248GB owner_controller=1A lun_id=9
create lun name=lun10 pool_id=5 capacity=2248GB owner_controller=1B lun_id=10
create lun name=lun11 pool_id=6 capacity=2248GB owner_controller=1C lun_id=11
create lun name=lun12 pool_id=6 capacity=2248GB owner_controller=1D lun_id=12
create lun name=lun13 pool_id=7 capacity=2248GB owner_controller=1C lun_id=13
create lun name=lun14 pool_id=7 capacity=2248GB owner_controller=1D lun_id=14
create lun name=lun15 pool_id=8 capacity=2248GB owner_controller=1A lun_id=15
create lun name=lun16 pool_id=8 capacity=2248GB owner_controller=1B lun_id=16

create lun name=lun17 pool_id=9 capacity=2248GB owner_controller=2A lun_id=17
create lun name=lun18 pool_id=9 capacity=2248GB owner_controller=2B lun_id=18
create lun name=lun19 pool_id=10 capacity=2248GB owner_controller=2C lun_id=19
create lun name=lun20 pool_id=10 capacity=2248GB owner_controller=2D lun_id=20
create lun name=lun21 pool_id=11 capacity=2248GB owner_controller=2C lun_id=21
create lun name=lun22 pool_id=11 capacity=2248GB owner_controller=2D lun_id=22
create lun name=lun23 pool_id=12 capacity=2248GB owner_controller=2A lun_id=23
create lun name=lun24 pool_id=12 capacity=2248GB owner_controller=2B lun_id=24

create lun name=lun25 pool_id=13 capacity=2248GB owner_controller=3A lun_id=25
create lun name=lun26 pool_id=13 capacity=2248GB owner_controller=3B lun_id=26
create lun name=lun27 pool_id=14 capacity=2248GB owner_controller=3C lun_id=27
create lun name=lun28 pool_id=14 capacity=2248GB owner_controller=3D lun_id=28
create lun name=lun29 pool_id=15 capacity=2248GB owner_controller=3C lun_id=29
```

```
create lun name=lun30 pool_id=15 capacity=2248GB owner_controller=3D lun_id=30
create lun name=lun31 pool_id=16 capacity=2248GB owner_controller=3A lun_id=31
create lun name=lun32 pool_id=16 capacity=2248GB owner_controller=3B lun_id=32

-----

create lun_group name=lg lun_group_id=1

-----

add lun_group lun lun_group_id=1 lun_id_list=1-4,9-12,17-20,25-28
add lun_group lun lun_group_id=1 lun_id_list=5-8,13-16,21-24,29-32
```

Step 2 - Create Mapping View, Host Group and Host

The portion of the ***mklun.txt*** command file, listed below, includes all the CLI commands to perform the following actions:

- Create a mapping view
- Create a host group
- Create 13 hosts
- Add the 13 hosts to the host group
- Add the host group and the LUN group to the mapping view
- Add the FC port's WWN to the 13 hosts

The command file described above is included in the Supporting Files (see Appendix A) and listed below.

mklun.txt

```
create mapping_view name=mv mapping_view_id=1

-----

create host_group name=hg host_group_id=1

-----

create host name=h1 operating_system=Linux host_id=1
create host name=h2 operating_system=Linux host_id=2
create host name=h3 operating_system=Linux host_id=3
create host name=h4 operating_system=Linux host_id=4
create host name=h5 operating_system=Linux host_id=5
create host name=h6 operating_system=Linux host_id=6
create host name=h7 operating_system=Linux host_id=7
create host name=h8 operating_system=Linux host_id=8
create host name=h9 operating_system=Linux host_id=9
create host name=h10 operating_system=Linux host_id=10
create host name=h11 operating_system=Linux host_id=11
create host name=h12 operating_system=Linux host_id=12
create host name=h13 operating_system=Linux host_id=13

-----

add host_group host host_group_id=1 host_id_list=1,2,3,4,5,6,7,8,9,10,11,12,13
```

```
-----  
add mapping_view host_group mapping_view_id=1 host_group_id=1  
add mapping_view lun_group mapping_view_id=1 lun_group_id=1  
-----
```

```
add host initiator host_id=1 initiator_type=FC wwn=21000024ff5332ab  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff5470a4  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff5470a5  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3cc528  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3cc529  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff543b14  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff543b15  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff4380b6  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff4380b7  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff2d9192  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff2f3aac  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff2d9193  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3e093a  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff3e093b  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff2f3aad  
add host initiator host_id=1 initiator_type=FC wwn=21000024ff5332aa
```

```
add host initiator host_id=2 initiator_type=FC wwn=21000024ff4b826a  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff4b826b  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff536ac2  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff536ac3  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff403916  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff403917  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff8af430  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff8af431  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff5f894e  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff5f894f  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff55c634  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff55c635  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff35696e  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff35696f  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff3cb6b8  
add host initiator host_id=2 initiator_type=FC wwn=21000024ff3cb6b9
```

```
add host initiator host_id=3 initiator_type=FC wwn=21000024ff53337c  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff53337d  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc34e  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc34f  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff53330a  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff53330b  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc4ee  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc4ef  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc294  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4bc295  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4c2ffe  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff4c2fff  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff5332d4  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff5332d5  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff533396  
add host initiator host_id=3 initiator_type=FC wwn=21000024ff533397
```

```
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332e4  
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332e5  
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332b4
```

```
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332b5
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5f8c1e
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5f8c1f
add host initiator host_id=4 initiator_type=FC wwn=21000024ff4bc459
add host initiator host_id=4 initiator_type=FC wwn=21000024ff8e8dde
add host initiator host_id=4 initiator_type=FC wwn=21000024ff8e8ddf
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5f8ca6
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5f8ca7
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332d2
add host initiator host_id=4 initiator_type=FC wwn=21000024ff5332d3
add host initiator host_id=4 initiator_type=FC wwn=21000024ff8e8bca
add host initiator host_id=4 initiator_type=FC wwn=21000024ff8e8bcb
add host initiator host_id=4 initiator_type=FC wwn=21000024ff4bc458

add host initiator host_id=5 initiator_type=FC wwn=21000024ff36e715
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5333cc
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5333cd
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4c300c
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4c300d
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5c3ba6
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5c3ba7
add host initiator host_id=5 initiator_type=FC wwn=21000024ff8e8e72
add host initiator host_id=5 initiator_type=FC wwn=21000024ff8e8e73
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4bc290
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5332b6
add host initiator host_id=5 initiator_type=FC wwn=21000024ff4bc291
add host initiator host_id=5 initiator_type=FC wwn=21000024ff2ce37a
add host initiator host_id=5 initiator_type=FC wwn=21000024ff2ce37b
add host initiator host_id=5 initiator_type=FC wwn=21000024ff5332b7
add host initiator host_id=5 initiator_type=FC wwn=21000024ff36e714

add host initiator host_id=6 initiator_type=FC wwn=2101001b32b308ae
add host initiator host_id=6 initiator_type=FC wwn=21000024ff8af4e2
add host initiator host_id=6 initiator_type=FC wwn=21000024ff8af4e3
add host initiator host_id=6 initiator_type=FC wwn=21000024ff53b652
add host initiator host_id=6 initiator_type=FC wwn=21000024ff53b653
add host initiator host_id=6 initiator_type=FC wwn=21000024ff5333c6
add host initiator host_id=6 initiator_type=FC wwn=21000024ff5333c7
add host initiator host_id=6 initiator_type=FC wwn=21000024ff533310
add host initiator host_id=6 initiator_type=FC wwn=21000024ff533311
add host initiator host_id=6 initiator_type=FC wwn=21000024ff2b88c6
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4038ce
add host initiator host_id=6 initiator_type=FC wwn=21000024ff2b88c7
add host initiator host_id=6 initiator_type=FC wwn=21000024ff5c26ea
add host initiator host_id=6 initiator_type=FC wwn=21000024ff5c26eb
add host initiator host_id=6 initiator_type=FC wwn=21000024ff4038cf
add host initiator host_id=6 initiator_type=FC wwn=2100001b329308ae

add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9cc0
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9cc1
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7470
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7471
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a8b20
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a8b21
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7420
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7421
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7410
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1c7411
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9c30
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9c31
add host initiator host_id=7 initiator_type=FC wwn=2001000e1e3045cc
```

```
add host initiator host_id=7 initiator_type=FC wwn=2001000e1e3045cd
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9e30
add host initiator host_id=7 initiator_type=FC wwn=2100000e1e1a9e31

add host initiator host_id=8 initiator_type=FC wwn=21000024ff535125
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4958c4
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4958c5
add host initiator host_id=8 initiator_type=FC wwn=21000024ff545060
add host initiator host_id=8 initiator_type=FC wwn=21000024ff545061
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4b91a8
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4b91a9
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4b900c
add host initiator host_id=8 initiator_type=FC wwn=21000024ff4b900d
add host initiator host_id=8 initiator_type=FC wwn=21000024ff543a5e
add host initiator host_id=8 initiator_type=FC wwn=21000024ff543be6
add host initiator host_id=8 initiator_type=FC wwn=21000024ff543a5f
add host initiator host_id=8 initiator_type=FC wwn=21000024ff2c94ec
add host initiator host_id=8 initiator_type=FC wwn=21000024ff2c94ed
add host initiator host_id=8 initiator_type=FC wwn=21000024ff543be7
add host initiator host_id=8 initiator_type=FC wwn=21000024ff535124

add host initiator host_id=9 initiator_type=FC wwn=21000024ff3fafbb
add host initiator host_id=9 initiator_type=FC wwn=21000024ff4a108a
add host initiator host_id=9 initiator_type=FC wwn=21000024ff4a108b
add host initiator host_id=9 initiator_type=FC wwn=21000024ff4b81a0
add host initiator host_id=9 initiator_type=FC wwn=21000024ff4b81a1
add host initiator host_id=9 initiator_type=FC wwn=21000024ff756e88
add host initiator host_id=9 initiator_type=FC wwn=21000024ff756e89
add host initiator host_id=9 initiator_type=FC wwn=21000024ff53330c
add host initiator host_id=9 initiator_type=FC wwn=21000024ff53330d
add host initiator host_id=9 initiator_type=FC wwn=21000024ff2b0f4e
add host initiator host_id=9 initiator_type=FC wwn=21000024ff5338b4
add host initiator host_id=9 initiator_type=FC wwn=21000024ff2b0f4f
add host initiator host_id=9 initiator_type=FC wwn=21000024ff540bba
add host initiator host_id=9 initiator_type=FC wwn=21000024ff540bbb
add host initiator host_id=9 initiator_type=FC wwn=21000024ff5338b5
add host initiator host_id=9 initiator_type=FC wwn=21000024ff3fafba

add host initiator host_id=10 initiator_type=FC wwn=21000024ff3c02dd
add host initiator host_id=10 initiator_type=FC wwn=21000024ff371eec
add host initiator host_id=10 initiator_type=FC wwn=21000024ff371eed
add host initiator host_id=10 initiator_type=FC wwn=21000024ff4a4f8c
add host initiator host_id=10 initiator_type=FC wwn=21000024ff4a4f8d
add host initiator host_id=10 initiator_type=FC wwn=21000024ff756da2
add host initiator host_id=10 initiator_type=FC wwn=21000024ff756da3
add host initiator host_id=10 initiator_type=FC wwn=21000024ff5439e4
add host initiator host_id=10 initiator_type=FC wwn=21000024ff5439e5
add host initiator host_id=10 initiator_type=FC wwn=21000024ff5bf518
add host initiator host_id=10 initiator_type=FC wwn=21000024ff5bf519
add host initiator host_id=10 initiator_type=FC wwn=21000024ff4bdfc4
add host initiator host_id=10 initiator_type=FC wwn=21000024ff4bdfc5
add host initiator host_id=10 initiator_type=FC wwn=21000024ff455ed2
add host initiator host_id=10 initiator_type=FC wwn=21000024ff455ed3
add host initiator host_id=10 initiator_type=FC wwn=21000024ff3c02dc

add host initiator host_id=11 initiator_type=FC wwn=21000024ff533331
add host initiator host_id=11 initiator_type=FC wwn=21000024ff49ae54
add host initiator host_id=11 initiator_type=FC wwn=21000024ff49ae55
add host initiator host_id=11 initiator_type=FC wwn=21000024ff533338
add host initiator host_id=11 initiator_type=FC wwn=21000024ff533339
add host initiator host_id=11 initiator_type=FC wwn=21000024ff4bc1f0
```



```
add host initiator host_id=11 initiator_type=FC wwn=21000024ff4bc1f1
add host initiator host_id=11 initiator_type=FC wwn=21000024ff35696c
add host initiator host_id=11 initiator_type=FC wwn=21000024ff35696d
add host initiator host_id=11 initiator_type=FC wwn=21000024ff4bc2d6
add host initiator host_id=11 initiator_type=FC wwn=21000024ff4bc2d7
add host initiator host_id=11 initiator_type=FC wwn=21000024ff535126
add host initiator host_id=11 initiator_type=FC wwn=21000024ff535127
add host initiator host_id=11 initiator_type=FC wwn=21000024ff3cbb98
add host initiator host_id=11 initiator_type=FC wwn=21000024ff3cbb99
add host initiator host_id=11 initiator_type=FC wwn=21000024ff533330

add host initiator host_id=12 initiator_type=FC wwn=2100000e1e289d91
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a940
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a941
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a730
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a731
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a830
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a831
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e23ae80
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e23ae81
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a4d0
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a4d1
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a7f0
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e28a7f1
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e289ec0
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e289ec1
add host initiator host_id=12 initiator_type=FC wwn=2100000e1e289d90

add host initiator host_id=13 initiator_type=FC wwn=2100000e1e28a9a1
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1c7490
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1c7491
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e28a4e0
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e28a4e1
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1e0100
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1e0101
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1c7430
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1c7431
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e23b2e0
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e23b2e1
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1a5640
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e1a5641
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e23b2c0
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e23b2c1
add host initiator host_id=13 initiator_type=FC wwn=2100000e1e28a9a0
```

Step 3 - Create Volumes on the Host Systems

The *mkvolume.sh* shell script, listed below, is invoked on one of the Host Systems to perform the following actions:

- Create 32 physical volumes
- Create a volume group for the 32 physical volumes
- Create 18 Logical Volumes for ASU-1
- Create 18 Logical Volumes for ASU-2
- Create 2 Logical Volumes for ASU-3

The shell script described above is included in the Supporting Files (see Appendix A) and listed below.

mkvolume.sh

```
pvcreate /dev/sdb
pvcreate /dev/sdc
pvcreate /dev/sdd
pvcreate /dev/sde
pvcreate /dev/sdf
pvcreate /dev/sdg
pvcreate /dev/sdh
pvcreate /dev/sdi
pvcreate /dev/sdj
pvcreate /dev/sdk
pvcreate /dev/sdl
pvcreate /dev/sdm
pvcreate /dev/sdn
pvcreate /dev/sdo
pvcreate /dev/sdp
pvcreate /dev/sdq
pvcreate /dev/sdr
pvcreate /dev/sds
pvcreate /dev/sdt
pvcreate /dev/sdu
pvcreate /dev/sdv
pvcreate /dev/sdw
pvcreate /dev/sdx
pvcreate /dev/sdy
pvcreate /dev/sdz
pvcreate /dev/sdaa
pvcreate /dev/sdab
pvcreate /dev/sdac
pvcreate /dev/sdad
pvcreate /dev/sdae
pvcreate /dev/sdaf
pvcreate /dev/sdag

vgcreate vg1 /dev/sdb /dev/sdc /dev/sdd /dev/sde /dev/sdf /dev/sdg /dev/sdh
/dev/sdi /dev/sdj /dev/sdk /dev/sdl /dev/sdm /dev/sdn /dev/sdo /dev/sdp
/dev/sdq /dev/sdr /dev/sds /dev/sdt /dev/sdu /dev/sdv /dev/sdw /dev/sdx
/dev/sdy /dev/sdz /dev/sdaa /dev/sdab /dev/sdac /dev/sdad /dev/sdae /dev/sdaf
/dev/sdag

lvcreate -n asu101 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu102 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu103 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu104 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu105 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu106 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu107 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu108 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu109 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu110 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu111 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu112 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu113 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu114 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu115 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu116 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu117 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu118 -i 32 -I 512 -C y -L 1779g vg1
```

```
lvcreate -n asu201 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu202 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu203 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu204 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu205 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu206 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu207 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu208 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu209 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu210 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu211 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu212 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu213 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu214 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu215 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu216 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu217 -i 32 -I 512 -C y -L 1779g vg1
lvcreate -n asu218 -i 32 -I 512 -C y -L 1779g vg1

lvcreate -n asu301 -i 32 -I 512 -C y -L 3558g vg1
lvcreate -n asu302 -i 32 -I 512 -C y -L 3558g vg1
```

APPENDIX E: CONFIGURATION INVENTORY

An inventory of the Tested Storage Configuration was collected during the execution the script *full_run.sh*. It generated the following log file:

- ***profile1_volume.log*** List of configured volumes before the INIT Phase.
- ***profile1_storage.log*** List of configured storage before the INIT Phase.
- ***Profile2_volume.log*** List of configured volumes after TSC restart.
- ***Profile2_storage.log*** List of configured storage after TSC restart.

The above log files are included in the Supporting Files (see Appendix A).

APPENDIX F: WORKLOAD GENERATOR

The ASUs accessed by the SPC-1 workload generator, are defined using the script ***slave_asu.asu***.

The phases of the benchmark are executed using the script ***full_run.sh***. The script pauses at the end of the PERSIST_1 test phase. Once the TSC has been restarted, the PERSIST_2 test phase is executed by pressing ENTER from the console where the script has been invoked.

The above scripts are included in the Supporting Files (see Appendix A) and listed below.

slave_asu.asu

```
ASU=1
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu101
DEVICE=/dev/vg1/asu102
DEVICE=/dev/vg1/asu103
DEVICE=/dev/vg1/asu104
DEVICE=/dev/vg1/asu105
DEVICE=/dev/vg1/asu106
DEVICE=/dev/vg1/asu107
DEVICE=/dev/vg1/asu108
DEVICE=/dev/vg1/asu109
DEVICE=/dev/vg1/asu110
DEVICE=/dev/vg1/asu111
DEVICE=/dev/vg1/asu112
DEVICE=/dev/vg1/asu113
DEVICE=/dev/vg1/asu114
DEVICE=/dev/vg1/asu115
DEVICE=/dev/vg1/asu116
DEVICE=/dev/vg1/asu117
DEVICE=/dev/vg1/asu118
```

```
--
ASU=2
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu201
DEVICE=/dev/vg1/asu202
DEVICE=/dev/vg1/asu203
DEVICE=/dev/vg1/asu204
DEVICE=/dev/vg1/asu205
DEVICE=/dev/vg1/asu206
DEVICE=/dev/vg1/asu207
DEVICE=/dev/vg1/asu208
DEVICE=/dev/vg1/asu209
DEVICE=/dev/vg1/asu210
DEVICE=/dev/vg1/asu211
DEVICE=/dev/vg1/asu212
DEVICE=/dev/vg1/asu213
DEVICE=/dev/vg1/asu214
DEVICE=/dev/vg1/asu215
```

```
DEVICE=/dev/vg1/asu216
DEVICE=/dev/vg1/asu217
DEVICE=/dev/vg1/asu218
--
ASU=3
OFFSET=0
SIZE=0
DEVICE=/dev/vg1/asu301
DEVICE=/dev/vg1/asu302
```

full_run.sh

```
#!/bin/sh
expect shstorage.tcl > profile1_storage.log
date > profile1_volume.log
lvdisplay >> profile1_volume.log
date >> profile1_volume.log

spc1 -run SPC1_INIT -iops 45000 -storage slave_asu.asu -output
~/newtool/spc1_INIT_45k_iops -master 13host.HST
spc1 -run SPC1_VERIFY -iops 100 -storage slave_asu.asu -output
~/newtool/spc1_VERIFY1_100_iops
spc1 -run SPC1_METRICS -iops 2340000 -storage slave_asu.asu -output
~/newtool/spc1_METRICS_2340k_iops -master 13host.HST
spc1 -run SPC1_VERIFY -iops 100 -storage slave_asu.asu -output
~/newtool/spc1_VERIFY2_100_iops
spc1 -run SPC1_PERSIST_1 -iops 585000 -storage slave_asu.asu -output
~/newtool/spc1_PERSIST_585k_iops -master 13host.HST
echo "Power cycle TSC, then Enter to continue"
read

expect shstorage.tcl > profile2_storage.log
date > profile2_volume.log
lvdisplay >> profile2_volume.log
date >> profile2_volume.log
spc1 -run SPC1_PERSIST_2 -iops 585000 -storage slave_asu.asu -output
~/newtool/spc1_PERSIST_585k_iops -master 13host.HST
```